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REPORT AND RECOMMENDATIONS
of the
UTILIZATION RESEARCH AND DEVELOPMENT ADVISORY COMMITTEE

Developed at its First Meeting
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Preface

The first meeting of the Utilization Research and Development Advisory Committee was held in Philadelphia, Pennsylvania, on November 18-21, 1963, with eight of its eleven members present for all sessions. Mervyn Wangenheim and William V. Pringle were unable to attend any of the sessions; Dr. D. M. Doty attended only the Monday sessions. As a basis for its comments and recommendations, the Committee made a systematic review of the Department's research program as summarized in the July 1, 1963, Progress Reports from the Eastern, Southern, Northern, and Western Utilization Research and Development Divisions. The Progress Report material was supplemented by discussions with the Directors of the above-mentioned divisions which covered demonstrations of accomplishments, plans for use of current resources through the next fiscal year, and problems requiring new or additional research. Dr. G. W. Irving, Deputy Administrator for Nutrition, Consumer and Industrial Use Research, ARS, acted as Chairman and participated with Dr. E. C. Elting, Deputy Administrator for Research Planning and Coordination, ARS, and Dr. B. D. Joy, Assistant to the Administrator, ARS, in a discussion of administrative and budgetary developments during the past year.

During the Monday morning session, Dr. C. A. Greenleaf, Associate Director of the National Canners Association, Washington, D. C., presented a statement concerning the Department's utilization research and development program. The Committee also received statements and recommendations from the National Flaxseed Processors Association and the Poultry and Egg National Board which it considered preparatory to making its own comments and recommendations.

On Wednesday, the Committee visited the Eastern Utilization Research and Development Division laboratory at Wyndmoor, Pennsylvania. It visited some of the laboratories and the pilot plant area and heard discussions by scientists and engineers of their basic and developmental research.

After a careful review of the information available and based upon current and future needs for new information and the seriousness of problems faced by utilization industries, the Committee made the following comments and recommendations to the Secretary of Agriculture.

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Additional copies of this report may be obtained from Roy Magruder, Executive Secretary, Utilization Research and Development Advisory Committee, Office of Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C. 20250.

REGIONAL RESEARCH

Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, before the Association of State Universities and Land-Grant Colleges, Chicago, Ill., November 13, 1963.

I think of regional research in agriculture as a meeting place, a common ground of understanding, between State and Federal research. It probably requires more give and take from all of us than any other form of cooperative research.

Federal-State cooperation in regional research is primarily a development of this century. As we all realize, its concepts developed slowly.

Most of the concern of the U. S. Department of Agriculture has, of course, always been with problems of broad regional or national significance. Developments of the 1930's advanced such investigations. Provisions of the Bankhead-Jones Act in 1935 for new regional laboratories and expanded research, and the later establishment of our four utilization laboratories, launched the Department into broadened research on regional needs. In 1936, the chief of the Office of Experiment Stations was made Director of Research for the Department -- a step which promoted cooperation between USDA, the States, and other agencies in research planning and coordination.

In 1946, the Research and Marketing Act provided the first funds for a formal, continuing program of cooperative regional research, and gave increased emphasis to the development of policies and procedures for such research. Since then, a wealth of new knowledge has been compiled. Regional research has come far, and continuing cooperation assures a bright future.

As such research gains momentum, the U. S. Department of Agriculture and its Agricultural Research Service strive continually to fulfill their commitments and responsibilities. ARS scientists have worked on a large proportion of the regional projects, whose numbers have grown from 50, in 1947, to almost 200 now under way. Federal scientists conduct research on two-thirds of the regional projects and serve with all of the technical committees.

When Dr. Byron T. Shaw, Administrator of ARS, addressed your Association in 1958, he laid down principles for redirecting and concentrating ARS activities to speed the development of regional centers for research. These principles have since been restated and underscored by the Secretary of Agriculture.

For a few minutes I'd like to reverse our present involvement in five-year plans for the <u>future</u>. Let's look <u>back</u> at the progress ARS has made in applying the principles outlined five years ago.

Our first job, as Dr. Shaw saw it, was to determine the areas in which ARS could make its greatest contribution to solving problems of regional and national importance. Our second job was to examine our research activities at each location -- in each area -- and determine what our future course should be.

Our commitment to teamwork research -- the combined efforts of scientists in many disciplines -- lends breadth and depth both to the research attack and to the scientists' own development.

This approach has made for fewer and better "centers of excellence" in research. Top-flight scientists, in their increasingly sophisticated studies, require substantial back-stopping. Last year, the supporting staff and operating costs of each ARS scientist averaged almost $26,000. Ideally, we believe it should be almost a third higher -- about $33,500. A scientist's work may require world-wide explorations, electron microscopes, atomic energy materials, or industrial pilot plants, as well as the sub-professional and administrative assistance that is so often inadequate in small laboratories.

ARS has closed out many small, isolated field stations and moved the scientists to larger laboratories. Today, we have 221 field locations of farm research -- 41 fewer than we had in 1958. The reduction trend continues.

Dr. Shaw also said our research centers should be, to the greatest possible extent, a part of the State agricultural colleges and experiment stations.

In the past seven years, ARS has put more than $34 million into construction of 32 large building projects -- now completed or in process. The cost of these laboratories, offices, and supporting buildings ranges from $120,000 to the $17 million that went into the National Animal Disease Laboratory at Ames. Of these 32 facilities, 27 are located near land-grant colleges or universities -- many on the campuses -- or near State agricultural experiment stations or substations. More than 89 percent of the $34 million was spent here.

This record speaks for itself. Our plans for future facilities follow this policy.

However, there will always be a need, we believe, to locate some Federal research away from State facilities. Urban growth and rising costs of land pose problems. Campuses of the future must stretch to accommodate bulging student populations, and some research facilities may have to retreat.

We believe that both State and Federal facilities should be available for housing both State and Federal people engaged in cooperative research. Our progress in putting this principle to work has been slow. Up to now, ARS scientists have more often been guests than hosts to State scientists. The Department has about 2,300 employees working on college campuses and State-owned field stations and spends approximately $20 million at these locations. As enlarged Federal facilities become available on campuses, we expect to have more State people sharing our laboratories in team research.

Joint planning is now going on for developing, from the earliest stages, the State and Federal facilities of the future. It should produce a network of publicly supported centers we can all be proud of. Only by appraising our own and each other's needs can we establish logical priorities and locate research where it can be done most efficiently.

Public Law 88-74 will assist the States in providing additional research facilities at experiment stations. We hope it may be a stimulus for acknowledging competence and providing for concentration of the research effort.

In our planning, we welcome the counsel of the USDA-State team the Secretary set up this year. It is appraising the needs for future research, and particularly the division of research efforts. In the light of this appraisal, it is reviewing the Department's long-range projections of needs for new or improved facilities. The team's help in establishing priorities for our building program, both at Beltsville and in the States, will coordinate the total research effort more closely.

Federal grants have helped to support a broad base for agricultural science and scientists for about three-quarters of a century. Research needs both institutional grants and grants to support talent where it exists. We in ARS are still new in administering this second type of grants, for basic research, but we feel that they can contribute greatly to the growth of individual scientists.

Results are beginning to come in from a third kind of Federal grant -- those made under Public Law 480 for research by foreign scientists. As you know, sales of surplus agricultural products abroad pay for this research. The studies must benefit the agriculture of the United States. Our first such grants were made five years ago; we now have more than 400 in force.

We are impressed with both the quality of this research and the caliber of these scientists. Among them are even a few Nobel prize winners.

P. L. 480 grants offer a unique opportunity to secure basic information on plants and animals, and on pests we do not want, from distant regions that may be similar to ours in geography or climate. Here we could profit from more joint planning, and we welcome your counsel on regional problems that would benefit from such research.

In developing jointly planned, cooperative research programs, administrators and scientists alike face complex questions. Has someone already done research that we are thinking about undertaking? How can we dovetail our research planning with studies already underway? How can we keep up to date in our fields? Only adequate compilation and retrieval of scientific information can answer these questions.

Several new developments, as well as continuing services, can help us to cope better with the rising tide of science information. I'd like to mention a few that may interest or involve us.

A Section of the American Association for the Advancement of Science is trying to develop a science newspaper on a broad national basis. As yet, it has no sponsor. The Section hopes to develop a sample copy of "The Daily Scientist" -- that's its proposed title -- for groups of scientists to criticize and evaluate.

As to scientific journals, nobody knows whether thousands are being published today, or hundreds of thousands. The Biological Serials Record Center at Washington, D. C., is attempting to provide a worldwide, comprehensive pool of information on all journals, periodicals, and other biological materials that are published serially.

The National Referral Center for Science and Technology -- just established at the Library of Congress -- is designed to put scientists and engineers in touch with all the country's information resources. The Center plans to issue a directory of such sources next March. This clearinghouse will act as a switching point for requests, referring the questioner to the best available centers or experts. That may mean <u>your</u> institution -- or <u>you</u>.

Particularly useful in the planning of research is the Science Information Exchange of the Smithsonian Institution. It's a clearinghouse for information on current research actually in progress. Both government and non-government agencies participate. The Exchange has records on some 40,000 projects currently active in the life sciences, and about 20,000 in the physical sciences.

Information on ARS research has always been available to State people. However, the interchange of such information will be elaborated and improved when both State stations and our Central Project Office have cards on each other's projects on file. Cards describing the 3,200 ARS research projects are being printed for distribution next year. In the near future, there should be complete exchange of information on research now in progress.

The multiple-use reports of progress that the Department now puts out annually are available to others interested in research planning. They combine two former reports, and are an excellent source of information on what each division is doing.

These and many other available services should help to coordinate both the planning and the execution of research.

Regional research is now in position to respond quickly to emergency needs with the aid of two special funds . . . your central research fund, established on recommendation of the Committee of Nine, and the contingency research funds of ARS, which is now in its third year.

When the cereal leaf beetle was first found in the north-central region last year, the States and ARS lost no time in getting both control measures and research under way to halt its spread. In some parts of Europe, this pest of grains sometimes destroys half the crop. We don't want to see what it might do if it reached major grain-growing regions of the United States.

Regional research can look back on many fine accomplishments. The fact that it is impossible to single out any one of them as the finest, the most far-reaching, the greatest achievement proves their wide impact on our diverse agriculture.

If Dr. John L. Creech, one of our most enthusiastic plant explorers, were here in my place, he would name the introduction and evaluation of new crops and plants as the greatest achievement of cooperative regional research. Certainly, before the regional introduction stations existed, our means of providing new germ plasm equally to all the research people who could use it were rather limited. And without the impetus given by the regional approach to evaluation, new crops -- such as crambe -- would be developed for industrial use very slowly.

The fruits and ornamentals Dr. Creech and his colleague, Dr. Scott, obtained on their recent trip to Russia are the first plant collections we have been able to make there since 1929. Breeding stocks of these plants will of course be directed through the four regional stations.

In the future, regional research will probably reach beyond agriculture more and more, cutting across organizational structures into many disciplines that explore man's total environment. Research may be stepped up in the behavioral sciences, in which we are even further behind than in the natural sciences.

Through it all, let us never lose sight of the fact that we serve three groups of people -- scientists, agricultural workers, and consumers.

We must free the time of the scientists -- the scientists of today and the scientists of tomorrow -- so that they can devote their best energies to creative work.

Their discoveries must be relayed to those who can make use of them -- the farmers and other workers in agriculture and its industries. Research emphasis must shift with the needs of these workers. Thcugh research serves big and little farms alike, that which will most benefit small farms and depressed rural areas is today being put to intensive use. And as more and more farms and ranches become outdoor playgrounds for cooped-up city dwellers, research must cope with new problems that the recreational uses of our soil and water raise.

Today, we are stepping up our efforts to make consumers realize what has always been true -- that they are the prime beneficiaries of agricultural research. Its pace must accelerate if we are to produce the food, the fiber, the oils, and the other agricultural products that the world's mounting populations will require.

Regional research, the meeting ground, can clarify and unify our task of serving all people. We must not disperse our energies or our funds in too many directions. Every fragment of investigation must bring some broad and pressing problem one step nearer solution.

As Federal services and State experiment stations join strength with strength, regional research can look forward to simplified and concerted attacks on the many problems that face American agriculture in the future.

TEAMWORK IN AGRICULTURAL RESEARCH

Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, at the first annual scientific workshop of the Animal Disease and Parasite Research Division at Ames, Iowa, May 20, 1963.

It is a pleasure to speak to a family group such as we have here. I believe we are all a part of the Agricultural Research Service either by choice or by marriage.

The wives of scientists, I find, absorb an amazing fund of knowledge about their husbands' work. Therefore, I feel that I am addressing a congregation of experts.

Sometimes our everyday routines loom so large that we lose sight of what our work, and that of our fellow scientists in ARS, mean to agriculture and America.

To sustain life, man -- and particularly woman -- must spend whatever time and effort is required to provide the necessary food, clothing, and shelter. Until that is done, nobody has time for any other pursuit. Here in the United States, our increasingly efficient agriculture has freed the vast majority of people for productive work of other kinds -- work which has developed a highly industrial economy and a comfortable standard of living.

I need not tell you the part research has played in making American agriculture the most efficient and productive in the world. Though ARS research finds application mostly on the Nation's farms, every citizen feels its impact.

It extends into every supermarket, helping to fill America's market basket with an abundance of nutritious, safe, and reasonably priced foods. Research adds work-free hours to a woman's day by providing convenience foods, wash-and-wear fabrics, and efficient household organization and management.

In order that such benefits may continue and multiply, research must flourish. A flow of original and useful ideas comes primarily from trained and talented scientists working in an environment of free scientific inquiry.

ARS needs to attract and hold imaginative scientists. It now recognizes more concretely than ever before the scientist's personal need to advance financially on the basis of merit. Today, an ARS scientist has an opportunity to receive compensation fully equal to that of persons in the agency's top administrative posts while continuing to pursue individual research.

Our Service's plan for more adequate recognition of outstanding research ability has been adopted by the Civil Service Commission for use, with minor modifications, throughout the Federal government. Thus originality and creativity, the qualities that add most to the stature of a well-trained scientist, are being more practically evaluated and rewarded.

Our research investments are something like our personal investments. We've all seen opportunities go by, during our lifetimes, to pick up at a bargain many a promising investment that would have paid off handsomely in the future. It may have been a piece of real estate, or an underpriced stock, or a part in a growing business.

The trouble was, we were so busy making ends meet that most of us had to let such opportunities slip by.

Research is somewhat like that. In most of our history, we've been so busy helping the farmer solve practical problems we've had little manpower or funds for basic research -- the research that eventually yields the greatest rewards. Now we need to build up a new reserve of fundamental knowledge of nature's why and how.

From the strictly practical viewpoint, basic research pays its way many times over. Any one of a number of discoveries in animal health, for example, has saved our economy enough to pay for all the research costs since 1894, when such Federal investigations began.

Basic research in ARS has been increased in a dozen years from 7 percent to nearly 35 percent of our total research effort. This is almost three times the proportion devoted to basic research in all Federal research and development. Eventually, we look forward to dividing every ARS research dollar equally between basic and applied research.

To supplement the basic work carried on in every research Division, we've also established 16 pioneering research groups in ARS. They are staffed by selected scientists of proved capacity to investigate the very limits of scientific understanding. These pioneering laboratories are unique in two respects: they are devoted solely to the development of new scientific laws and principles without concern for the solution of immediate practical problems; and their scientists are largely free of supervisory or administrative responsibilities.

Whether our research is basic or applied, the team approach, cooperative between disciplines and divisions, is becoming more and more essential. Seldom is an agricultural problem solely a problem in chemistry, or in engineering, or in virology. Its complexity often demands the concentrated efforts of specialists in many fields.

Science has, in fact, become so complex that on most long-range research we no longer ask, "Should we have a team approach?" but "How can we make multidisciplinary research most effective here?"

Next to capable scientists, facilities and equipment are the first essential. The present trend in State and Federal research is toward fewer but larger laboratories better equipped and staffed than small ones could afford to be. There, administrative "housekeeping" duties can be largely taken off the hands of scientists. Reference libraries and scientists in other disciplines are available. These opportunities are generally best at universities and State agricultural experiment stations.

Next, an atmosphere must be created that promotes free exchange of ideas. Seminars, work conferences, and occasional task forces can foster friendships and encourage mutual respect among members of the scientific community. Such meetings as the ADP workshop we are now attending, with its informal swapping of ideas, stimulate interest in working together to solve mutual scientific and related problems.

Scientists have of necessity been stationed, at times, at small laboratories and field locations where only two or three people in the community understood or appreciated their work and could discuss it. In the scientific community, however, the talk that goes on can whet and clarify one's own thinking while opening the mind to other disciplines and points of view.

Team research is at work at ARS stations in all our 50 States. Here at the National Animal Disease Laboratory, the entire effort is geared to this approach, which should intensify and expand as the various programs get further under way.

At Ithaca, New York, scientists in soil and water conservation, animal husbandry, and animal disease and parasite research are jointly attacking the complicated interrelationships between plants, soil, and animal nutrition.

At Athens, Georgia, the work at the new Southeast Poultry Research Laboratory will be cooperative between three Farm Research Divisions -- Animal Disease and Parasite Research, Animal Husbandry, and Agricultural Engineering. For the first time, a team will study intensively the combined effects of poultry disease, heredity, and environment.

Animal health scientists and entomologists cooperate on much research -- for example, at Denver, Colorado, and at Beltsville, Maryland, on diseases and their arthropod vectors; and at Kerrville, Texas, on effectiveness, safety, and toxicity of pesticides.

Although the importance of multidisciplinary research is readily recognized, it can never be a realistic substitute for individual effort and initiative. It should and must enhance and complement them. We believe that within the framework of coordinated team research the imaginative individual can still find the freedom conducive to uninhibited scientific inquiry.

Much of the overall ARS research program outside the Farm Research Divisions is of great interest in animal husbandry and health. For example, ARS human nutritionists are investigating the role of fats in our diet. Utilization research scientists are finding new uses for inedible animal fats in such things as plastics, waterbase paints, floor wax, and livestock feeds, and are developing a dry whole milk which shows promise for alleviating our dairy surplus problems.

It is with farm research, however, that I am most familiar. It is the oldest and most widely recognized activity of ARS. It ranges from tropical research in Puerto Rico, the Virgin Islands, and Hawaii to sub-arctic research in Alaska.

This year, our budget of $58,334,500 has been devoted to research by the six Farm Research Divisions at 212 locations throughout the United States and abroad. More than half these locations -- 130 -- are at Land-Grant colleges and their substations. Our professional scientists number more than 2,000.

Our work is carried out in cooperation with the States, with industry, and with the governments of foreign countries.

ARS supports research at State experiment stations through both contracts and cooperative agreements. In contrast to most of the executive departments of government, we have a strong in-house capability for research, and only about 1 percent of our total budget goes into contract research.

In our extensive program of cooperation with the States, ARS is usually concerned with broad regional or national interests; the State experiment station is usually interested in needs of the State and the region. The phenomenal spread of hybrid corn in the United States is largely the result of a cooperative breeding program between several States and the USDA.

In addition to our Stateside responsibilities for research beneficial to American agriculture, we have responsibilities which involve several farm research stations abroad. For example, research on foot-and-mouth disease is going on in the Netherlands; African swine fever is being studied in East Africa. Explorations for insects that will devour weeds are being made in the Mediterranean region and in Morocco; other foreign explorations for parasites of agricultural pests are headquartered in France. Research on insects, cotton breeding, and wheat seed increase is being conducted in Mexico.

Our other foreign research is conducted within the authority of Public Law 480. Under its provisions, research is financed with local currencies derived from the overseas sale of farm commodities which we produce in abundance. This research extends and supplements many types of work we are doing in the U. S.

Judging by progress made so far, these P.L. 480 projects will prove very valuable to both the countries involved and to the U. S. They will also enhance rapport with foreign scientists, and increase mutual respect, understanding, and communication.

There are obvious advantages to be derived from on-the-spot studies of foreign insects and diseases that ravage other countries and threaten our own. Under P.L. 480 grants, the Animal Disease and Parasite Research Division sponsors some 20 research projects on various aspects of animal diseases and parasites in 8 foreign countries. The dozen or so diseases may be as familiar as swine erysipelas and chronic respiratory diseases in chickens, or as exotic as African swine fever or babesiellosis of cattle. Emphasis given to parasites includes studies on horse bots in Turkey and certain leeches in Israel.

In this country, farm research is concerned with conserving soil and water resources, producing quality agricultural products efficiently, and protecting crops and livestock from the many hazards that beset them.

Probably most basic to life is conservation of our soil and water resources. In this widespread and diverse Nation, our conservation engineers located in many parts of the country may be figuring out how to irrigate a desert, drain a swamp, prevent a dust bowl from forming, and stem a flood -- all on the same day. Other scientists are exploring the fundamental relationships of soils, water, plants, and animals.

Our agricultural engineers devise concepts and systems which utilize men, materials, and energy in the most efficient possible combinations. To further mechanize crop harvesting, they've developed equipment to harvest several types of fruit at the rate of 30 to 50 trees an hour. To reduce labor in livestock production, they have perfected an automated feeding system which carries feed from bin to feeders as easily as you can pipe running water.

Scientists of the Crops Research Division have played a leading role and worked closely with the various States in developing information which has led to a change in selection of plants that farmers grow in their fields. These scientists have supplied new germ plasm and adapted foreign crops to our climate and methods of farming. They have fixed resistance to various diseases and insect pests in established crops, and tailored many crops to fit machine operations on the farm.

The Animal Husbandry Research Division is helping farmers to increase the efficiency with which feed is converted into meat, poultry, milk, and eggs. Research and critical evaluation of breeding and performance testing have resulted in improved milk producers, meat-type hogs, lean, tender beef, and meaty broilers. We are producing over 35 percent more beef per cow today than we were 25 years ago, nearly 25 percent more pork per sow, over 60 percent more milk per cow, and over 70 percent more eggs per hen.

The Animal Disease and Parasite Research Division develops defenses for the health of our $19-billion livestock, dairy, and poultry industry. You might call the trio of its principal laboratories the national institutes of animal health: NADL here at Ames for the study of domestic livestock diseases, our Plum Island Animal Disease Laboratory, off the coast of Long Island, New York, for foreign disease research, and the Parasitological Research Laboratory at Beltsville, Maryland.

The prospect is promising for biological control of animal parasites through use of vaccines, special management practices, and sanitation. No chemical residues on meat, or resistant strains of pests, could result from such an approach.

Studies on weed control, nematodes, and plant diseases in the Crops Research Division and the work of the Entomology Research Division comprise our other research defenses against the natural enemies of agriculture.

Entomologists continue to work on conventional chemical insecticides -- still the mainstay of agriculture's defense against insects. But our long concern with residues, together with the growing resistance of insects to chemicals, has led to a steady shift in emphasis over the years. We now devote about two-thirds of our entomological research to biological controls, specific chemical techniques, and basic explorations of the life processes of insects.

For example, from years of basic research has come a new defensive weapon against cabbage loopers. These insects damage more than a dozen different vegetables, field crops, and flowers. From 10 diseased loopers, insect pathologists can produce a pinch of grayish powder that contains enough virus particles to infect an acre of land with a disease deadly only to cabbage loopers.

Such research as this is often put to work in ARS regulatory programs -- programs that actively protect our crops, livestock, and food supply from diseases and pests.

Animal and plant quarantine inspectors stand guard at our ports and borders to protect against foreign pests and diseases of crops and livestock. They also help to keep our agricultural exports pest-free, and insure the purity and potency of veterinary biologics.

If foreign pests evade these guards and enter this country, the Plant Pest Control Division and the Animal Disease Eradication Division may launch cooperative Federal-State control or eradication programs against the invaders. It is usually better to eradicate such pests than to learn to live with them, and early detection makes this possible.

The Pesticides Regulation Division protects the public against fraudulent, ineffective, and unsafe chemicals used against farm, household, and human pests.

The Meat Inspection Division safeguards the purity and wholesomeness of our domestic, imported, and exported meats and meat products.

These six regulatory Divisions are both a proving ground and a showcase for much of the work conducted by the six Farm Research Divisions.

No pest eradication program can be effectively undertaken until research provides the tools. Sometimes we must launch new research in a hurry when a new pest or disease crosses our borders. However, in most cases regulatory work is best served by long-term basic research.

For example, the sterile-male principle, developed through ARS research, has worldwide implications. It led to eradication of the screwworm fly in the southeastern United States. Continuous release of insects that have been made sterile by radiation or chemicals can stop reproduction in the entire natural population of an injurious insect species and eventually eliminate it.

Teamwork with regulatory workers benefits research. Control programs can eliminate the time lag before a new research finding is put to work. Also, research and regulatory workers can together translate laboratory results into wide-scale application. Difficulties arise here, just as the erection of a seven-story building from a buleprint runs into snags neither the architect nor the contractor could have foreseen. Through further research and laboratory testing, regulatory workers often refine and in some instances shorten eradication procedures as programs progress.

Here, as in all our cooperative work, research and regulatory workers need to understand each other's problems . . . to communicate and plan together effectively . . . and to recognize and respect each other's contributions.

We can be proud of the record and the teamwork between research and regulatory programs. Because of it, several plant pests and diseases have been eradicated from this country -- for example, the parlatoria date scale, citrus canker, the Mediterranean fruit fly, and the citrus blackfly. Other plant pests are well on their way to eradication. Still others are being held in check by programs that are buying time until research can come up with practical eradication tools.

The same close teamwork has controlled or eradicated many animal diseases. Each new testing technique for brucellosis detection has been a milestone in its eventual eradication. When vesicular exanthema broke out in U. S. hogs, research resources were concentrated early enough for regulatory workers to design an effective program that eradicated VE from this country.

Since the 1890's, research and regulatory scientists have worked together to provide this country with a healthy livestock industry. Scientists regard the discovery that ticks transmit Texas fever as one of the great chapters in biomedical history. It not only led to the eradication of this cattle killer from the United States, but also unlocked the door to the role of vectors in human diseases . . . malaria, yellow fever, bubonic plague and, in fact, all of the arthropod-borne diseases of man, animals, and plants.

In closing, I'd like to give the viewpoint of the Surgeon General of the U. S. Public Health Service on the close relationship between human and animal health. In a speech last month, Dr. Luther L. Terry pointed out that the veterinary medical profession originated the concept of disease eradication, pointing the way for elimination of some of man's oldest and deadliest enemies.

After citing eradication of contagious pleuropneumonia, glanders -- a major public health problem at the time of the first World War -- foot-and-mouth disease, and fowl plague, Dr. Terry went on: "Now bovine tuberculosis is gone from most parts of the United States, and you are confidently envisioning the eradication of brucellosis."

"Many advances in experimental surgery could not have been made without animal research," he stated. "The story of the blue baby and achievements along similar lines are all the results of cooperation (between physicians and veterinarians) in this area of animal experimentation. Now we are finding animals useful to evaluate genetics, susceptibility to environmental influences, nutrition, and aging."

He spoke of a swiftly increasing interdependence between medical and veterinary medical science for the future, and predicted that "the public health service, then as now, will look to veterinary science for leadership and partnership in our joint adventure."

I want to echo Dr. Terry's hopes for cooperation between all of us in public service. It should begin in our own laboratories with teamwork between fellow scientists. It can expand to include all who share our aim -- the harnessing of natural forces for the betterment of man.

I. GENERAL COMMENTS AND RECOMMENDATIONS

Long Range Utilization Research Program. The Utilization Research and Development Advisory Committee commends the Department of Agriculture for its leadership in utilization research on farm products and strongly endorses the goals so well set forth on pages 7 and 8 in Senate Document No. 34, Strengthening Research on Utilization of Agricultural Commodities - A Report to Congress submitted by the Secretary of Agriculture, September 12, 1963.

It also agrees with the National Agricultural Research Advisory Committee's recommendations for program development on product development and processing made at its May 6-7, 1963, meeting.

Present agricultural crops now in excess of current needs are crops well adapted to increased farm production. These and new crops not now grown constitute a source of industrial raw material which is replenishable annually and can be tailored to the needs and volume demand of industry.

The Committee believes that utilization research should be planned and implemented for the long-range expansion of the agricultural economy of the Nation.

Basic Research. This Committee observed several instances where recently obtained basic research results are already making important contributions to the solution of problems which heretofore had been unsolved. Therefore it is the recommendation that fundamental or basic research continue to receive the major emphasis it deserves/ It is recognized that there is no sharp line of demarcation between basic and applied research. It is felt that Government laboratories should devote the major portion of their resources to basic research and that industry should be encouraged to assume more responsibility for applied research.

Contracts and Grants. The use of contracts and grants to cover some of the badly needed basic studies is a commendable part of the program. The use of Public Law 480 funds for research of a highly specialized nature with high manpower requirements that can be obtained at lower cost in foreign research laboratories is also recommended where such funds are available.

Research Cooperation and Coordination. The Committee commends the Federal and State agricultural research organizations for their coordinated and cooperative programs. The pooling of information in the joint USDA-State Experiment Station research project files and the inclusion of this information in National Science Information Exchange programs preclude duplication of effort. Cooperation of Federal and State personnel in the planning and execution of research at National, regional, and State levels, and location of USDA employees at universities, leads to close collaboration on research projects. It is believed that the proposed research grant and contract program of the Department will step up the rate of research accomplishment and allow the USDA to participate in the training and retraining of utilization research scientists.

With information now available in the National Science Information Exchange program, the Committee strongly urges that a Government-wide integrated, coordinated, and cooperative research program be developed as rapidly as possible. All Government agencies having an interest in research in a certain field should work together as a team on a jointly planned and cooperative program.

Public Image of Agricultural Research. Improvement of the public image of agricultural research will result when such research is viewed in the light of its major objective, namely, to provide all of our people with an abundance of high-quality food, fiber, and industrial and consumer products. The achievement of this goal is furthered by the fact that all who work in agricultural research are also consumers of agricultural products and as such are fully responsive to the interests of the general public and are thus guided in this constant striving for improvement.

Assistant Secretary of Agriculture for Research and Education. The Committee is gratified to note the Secretary of Agriculture's appreciation of the importance of agricultural research as evidenced by his request to the Congress for the creation of the post of Assistant Secretary of Agriculture for Research and Education.

Patent Policy of USDA. The Committee was asked to consider patent policy of USDA with respect to utilization research. The Committee, appreciating the importance of this decision, suggests that no change of policy be made until the Department makes a thorough survey of the views of industry and others interested, with respect to both U. S. and foreign patents.

Library Services. Library services are necessities at all levels of scientific activity. The explosion in scientific, technical, and commercial literature makes more difficult a scientist's awareness of old and new knowledge in his own and related fields, to avoid duplication of effort and to form a solid base for new work. Specialization in science requires specialization in information storage and retrieval and points up the need of the Department's own Library in Washington for the complete agricultural scientific literature of the entire world. This literature should be available as directly and completely as possible to its own scientists and to the public at large. The Committee hopes the approval of funds for planning the expansion of the National Agricultural Library will result in prompt action. Wherever P. L. 480 funds are available, a portion of them should be used for translation of foreign research reports into English.

Facilities, Instrumentation and Personnel. The Committee was impressed with the excellent staff, fine facilities and broad, comprehensive program of the utilization research work of the Agricultural Research Service and complimented it on its achievements to date in these respects.

The team approach to the solution of problems is a commendable one as it encourages the development of specialized equipment that can be used on a number of commodities being studied at each laboratory. Improved instrumentation and the development of new or improved analytical

techniques are essential to progress in utilization research and should be stressed in planning for the future. The investments in this new equipment and in the specially trained personnel required to operate it and the volume of work required for efficiency in its use can only be justified in rather large laboratories or aggregations of workers in related lines of endeavor. After full consideration of the present four main utilization research and development division laboratories, the Committee was of the opinion that these were sufficient in number to serve agriculture's research needs. As future needs for expansion arise, this expansion should be at the existing facilities for most efficient and effective operation. The development of such recognized scientific communities is in the best interest of the public.

In order to speed up the analysis of the large volumes of data being produced, the Committee recommends that computers be made available locally for each of the main laboratories at the earliest possible date.

Agricultural Raw Product Processing Plant Waste Disposal. Because of the rapid growth in population, the trend of more housing developments in normally rural areas, the greatly increased industrial expansion into formerly rural areas, the increasing use of natural resources for recreation purposes, we are now faced with problems of air, soil and water pollution, that are increasingly important and urgent.

Processors of agricultural products face a major problem in the disposal of solid and liquid wastes to avoid stream pollution and the creation of public nuisances. The growing scarcity of adequately pure (safe) water supply considerably aggravates this problem.

At the present time there is very little information and "know-how" available on the disposal of agricultural product processing plant wastes that will satisfactorily meet all present and anticipated future health regulations. Basic research is imperative on the components of these waste materials and how they can best be treated for economical disposal to avoid offensive odors, soil, water, and air contamination.

The Utilization Research and Development Divisions of ARS are urged to take immediate and positive steps in the initiation of this research and to cooperate fully with other State and/or Federal agencies that have any responsibilities in this problem.

Dissemination of Research Results. The Committee appreciates the efforts of the Utilization Research and Development Divisions in disseminating the results of their research through the usual series of Government publications, in scientific and technical journals and at conferences on commodity research in the different laboratories. In order that the rate and effectiveness of the commercialization of the results of research may be increased, it was recommended that new and additional techniques of communication be developed and/or used, beginning at first with those commodities where there is a large and organized processing sector of the industry such as the natural fibers field.

II. COMMENTS AND RECOMMENDATIONS ON CURRENT AND NEEDED RESEARCH

In recommending new or expanded research on problems listed in this section, the Committee recognizes that it is not its responsibility to delineate between research to be conducted within the Department and that to be conducted in cooperation with State Agricultural Experiment Stations and other research organizations. The recommendations made by the Committee are based on their judgment that the problems are important and that research is needed. The Committee did not establish any priorities as to importance of problems recommended.

CEREAL AND FORAGE CROPS

Industrial Utilization of Cereal Starches. The Committee recommended increased emphasis on fundamental research with cereal starches. It is felt that utilization would be enhanced by a better understanding of starch granule structure, and undoubtedly this will require a more complete understanding of molecular structure and chemical reactions of starch. It would also be of value to learn more about the role, and the locus of the non-carbohydrate constituents. Such fundamental information will undoubtedly pave the way for the needed new knowledge to facilitate the plasticization of starch films.

The Xanthide work has been most valuable and its further development probably could be left to the paper industry. Graft polymerization, however, is not that far advanced, and should continue to receive a considerable amount of attention.

Industrial Utilization of Wheat. The Committee subscribes wholeheartedly to basic and exploratory research on wheat fractions. It feels, however, that this should be heavily weighted toward the protein fraction in which wheat is truly unique. The proposed studies on the interaction of starch and protein opens an interesting area and probably is worth exploring. It fails to see where the diversion of one surplus crop such as wheat into markets traditionally supplied by another crop, also in surplus, is the best use of utilization research funds. If, however, such research will lead to products having unique properties not found in existing industrial materials derived from agricultural sources, then such research does have a place in the utilization research program.

Corn, Sorghum, and Other Feed Grains. Fundamental information on composition and compositional changes that occur in processing of corn, sorghum, and other feed grains are needed areas for research under the utilization research program.

Research on new human food products from corn and sorghum flours is a good area for investigation and should be initiated.

High Amylose Corn. High amylose corn has been custom-developed to fill an anticipated industrial need for a starch-bearing crop that might be suitable for producing films and fibers. The breeding program has been

going well, but it requires much analytical support to keep it oriented. Unexpectedly it has also been found that both the amylose and the amylopectin fractions are substantially different from those of conventional grain and may necessitate special treatments. Both fundamental and applied research are sorely needed in this area. This new corn product also requires special new milling techniques which need further research.

Fermentation of Cereal Grain Products. Our vast annual production of starches gives us a most attractive source of fermentable carbohydrates, and fermentation as a unit process provides a highly flexible method of converting this storehouse into a whole host of new and useful commodities. The Department has, at the Northern Utilization Research and Development Division, exceptionally fine facilities and personnel to exploit this almost untapped area. It has been traditional for the USDA to work in this area, it has proven most fruitful through the years, and it should be expanded to as high a rate as can be afforded.

Food and Feed Products from Wheat and Barley. It is urged that the work on chemical composition and physical properties of wheat and barley be accelerated to provide the basic information on which new and better food and feed products can be developed.

The work on new and improved wheat foods should be directed toward truly unique foods; process development work should be carried only to the point where it can be picked up by industry.

The work on flavor and freshness retention in baked products is very important. Here again emphasis should be placed on basic research directed toward finding the basic mechanisms of flavor development and loss, the constituents and interactions of flavor producing components. Similarly basic physical chemical studies on textural aspects of baked products should be expanded.

Rice Processing and Products. The program on basic chemical composition and physical properties should be stepped up as much as possible. The Committee recommends that both laboratories work on their respective investigations with pure strains of seed of known history from three leading varieties of rice simultaneously--two Southern varieties, Bluebonnet-50 long grain, Nato medium grain, and one Western variety, Caloro short grain. It is felt that the simultaneous study of these three varieties with greatly different gross cooking qualities will produce data which will be more useful sooner, than if only one variety is chosen.

As a result of the basic compositional studies, the factors affecting processing characteristics should be revealed.

Information is needed on the differences in chemical composition and cooking quality of white rice milled to various degrees and compared to parboiled rice processed to various degrees and milled to various degrees.

In addition to the studies on chemical and physical composition of raw rice, there is need for detailed study of the changes which take place

during cooking, with emphasis on histological and histochemical techniques which will reveal the in situ changes.

Work on the vitamin enrichment of rice should not be initiated.

Work on the high protein rice flours and air classification techniques should be expanded to produce special purpose flours. Microbiological studies similar to those on other cereal flours should be made since rice flour is potentially useful in many specialized food products where low microbial contamination is required.

It is recommended that a continuing program be initiated (possibly with P. L. 480 funds) whereby the Oriental and Indian literature on rice research is surveyed and detailed abstracts of important advances are translated for distribution to U. S. cereal chemists.

Forages and Feed--Processing and Products. The good work on the isolation and study of biological activity of both beneficial and toxic substances from feed and forage materials should be expanded so that ways and means of retaining the maximum amounts of beneficial nutrients and eliminating the adverse substances can be developed. Work should be continued on basic compositional studies and the correlation of composition with nutritional qualities.

COTTON, WOOL, AND OTHER FIBERS

Basic and Exploratory Investigations of Cotton. A thorough fundamental understanding of the structure and properties of the cotton fiber and of the mechanisms involved in its chemical and physical behavior is essential before a sound program can be formulated to investigate the optimum mechanical forces and chemical reactions needed for processing cotton fibers. Exploratory chemical and physical investigations can provide the building blocks for the processes and products of the future.

Chemical and physical finishing techniques offer the greatest promise for producing cotton fabrics with properties desired by the consumer. However, in arriving at the final fabric structure, the part which the physical construction of the yarns and fabric contributes to the final product should be kept constantly in mind and continued effort devoted to the development of optimum greige structures as a foundation for the production of desirable finished fabrics.

In preparing cotton fibers for final processing, use should be made of the many unusual means available. A continued investigation should be made of electrostatic and aerodynamic forces as an aid to cleaning and alignment.

Interrelations among Fiber, Yarn, and Fabric Properties of Cotton. Knowledge of the interrelations of fiber properties, yarn and cloth quality, and processing efficiency is essential if cotton is to maintain its competitive position in the textile industry. Such vital

information as the effect of fiber length distribution, elongation, and tenacity and inter-fiber friction of cotton fiber assemblies must become available to cotton processors. Southern Utilization Research and Development Division's vital work in this area should be continued.

Thorough knowledge of the effect of all these properties on the final product is needed. This knowledge cannot be obtained by existing instruments, and concerted work on the development of methods and instruments designed to determine these properties should be extended.

New and Improved Cotton Textile Machinery. The effort now underway on the development of totally new and unconventional methods of processing cotton can be of considerable help to mills in producing better cotton products at lower cost. Opening, blending, and thorough cleaning of cotton by radical new methods without fiber damage is a basic requirement of efficient cotton manufacture. Major emphasis should be given to machinery development in opening, blending, carding, and combing since many problems in these areas are peculiar to cotton. Concentration on radical new approaches is recommended so as to avoid duplication of efforts in industry or mere modification of conventional machinery.

Since the trend in textile machinery development in the United States and abroad is towards eventual elimination of the lap feed for carding, machine development should be directed toward other more vital fields.

Improvement of Wash-Wear Properties of Cotton Fabrics. The current emphasis on wash-wear finishes should be maintained. Although tremendous strides have been made in the industry, due in no small part to the pioneering work of the Department, there are still many obstacles to be overcome to produce optimum minimum care fabrics. Attention should be given, in planning new effort, to finishes which attain better minimum-care attributes without detracting from cotton's outstanding competitive features, namely, cool, soft feel and moisture transfer. Effort should be concentrated also on multi-purpose finishes combining wash-wear properties with soil and stain resistance. These would give cotton a definite advantage over so-called "easy-care" synthetics and lead to increased consumption of cotton.

Cotton Products with Special Properties. Further effort is essential toward the development of specialized cotton products with properties such as heat, rot, and weather resistance. In addition, special effort should be concentrated in permanent, non-toxic flame-resistant finishes for household textiles. The Committee endorses future work on cotton products with special properties.

Wool and Mohair Investigations. The Committee recommends an expansion of current explorations of chemicals and processes which modify wool and mohair fiber and in consequence result in improvement in the attributes of these fibers in yarn and textile structures. Special effort should be assigned to fiber modifications in bulk and in yarn and fabric which give (without serious change in the present desirable attributes of wool fibers) increased soil-and-stain resistance; wrinkle resistance of apparel fabrics; resistance to shrinkage or elongation in wetting and

cleaning; impart stretch and recovery properties and advance the commercial manufacture of improved minimum-care garments.

It is also recommended that the Department initiate studies of the attributes of blends of fibers, e.g., effect of blends of wool grades; wool and cotton blends and wool and synthetics, in which the wool components or part thereof shall have been modified chemically and/or physically with bond-forming agents and polymers. Development of blended wool fabrics with special attributes could expand wool consumption.

Extend the search for improved methods, having commercial applications, which, subsequent to chemical or physical modification of wool fibers, yarns or fabrics, affect the bulk or shape retention of the fiber or structure despite stress or deformations incident to regular use and cleaning. The physical modifications referred to are those of twisting, crimping, compacting, or other modifications of yarns or knitted or woven textile structures. Include in these studies their application to mohair fibers with the goal of modifications which permit economic processing of mohair in present woolen and worsted systems and which lead to new style appeals in apparel fabrics and garments.

FRUITS AND VEGETABLES

Compositional Studies. Common to the problems in processing all fruits, vegetables, and tree nuts is the matter of maintaining and improving the qualities of flavor, appearance, and texture. In many instances these characteristics are influenced by the effects of mechanical harvesting. Increasing knowledge of the basic constituents resulting from compositional studies of many of these commodities is making the task of solving these problems easier by research workers of both USDA and industry. Such compositional information, depending on the nature of the food product, contributes to the solution of the problems of preserving or enhancing the natural flavor and preventing off-flavor, preserving natural color or preventing darkening, stabilizing natural cloud in a liquid or accomplishing its clarification or of maintaining desirable texture. The Committee recommends the continuation of compositional research at an increased level of support.

As the basic compositional data indicate, the solution of practical problems of color, flavor, and texture should be sought by research on the important varieties of the species in the several important U. S. producing areas for the species.

Microbial Spoilage. Processors of fruits, vegetables, and tree nuts encounter considerable losses through microbial deterioration and spoilage. Research on this subject and on the biochemistry of the bacterial spores is of direct interest to the industry. Therefore, the Committee favors increased support for this research at the appropriate laboratories.

Cooperation on Biological Control of Pests. The Committee encourages the cooperation of utilization research personnel with entomological and pathological research workers to further expedite the biological materials approach to control of important insect and diseases of agricultural crops.

NEW AND SPECIAL PLANTS

Utilization Potential of Replacement Crops. The Committee believes that our economy can be improved by the introduction and development of new crops which could be used as a replacement for grain and other crops now in production above our immediate needs. It is recommended that expanded research in the following areas be implemented:

a. World search for, and introduction of, new crop plants.

b. Chemical characterization of new crop plants for such compounds as (1) seed oils of unusual fatty acid compositions, (2) mucilages and gums, (3) proteins and amino acids, and other components differing in composition from those of presently grown domestic crops.

c. Adaptation of prospective crops to the United States.

d. Search for industrial application for compounds resulting from this research. Among the new oilseeds discovered in this research and on which developmental research on application and processing methods needs to be carried out are (1) crambe abyssinica, a promising source of erucic acid for synthesis of rubber additives and new plastics, (2) vernonia anthelmentica, which has a content of epoxy fatty glycerides which are of use as plasticizers and stabilizers in the growing vinyl chloride plastic industry, (3) Dimorphatheca and Lesquerella, both of which contain hydroxyacids comparable to those in castor oil. The continuing uncertainties of foreign supplies of castor oil, and the cost limitations of domestic growth, strongly suggest a joint program of study of the quality and properties of these oils and the byproduct meals while these new oilseeds are under development as practical domestic crops.

Sugar Producing Crops. The Committee approves the current program to improve the processing and utilization of sugarcane and sugar beets and recommends that the work be expanded. Sugar is not currently in excess supply, but if industrial uses can be found the acreage could be rapidly expanded, and beet, cane, and sorghum could replace crops which growers produce in excess of demand.

The markets for industrial chemicals, plastics, protective coatings, etc. are large (more than 20 billion pounds per year) and growing rapidly.

Sucrose is an attractive raw material for the development of industrially useful products because it is produced in large quantities from sugarcane and sugar beets, and hence is already available at low prices (less than

10¢ per pound); produced from other United States crops, e.g., sweet sorghum; versatile chemically, and hence lends itself to chemical transformations into numerous products; polyfunctional in nature, and hence suitable for transformation into plastics, resins, and protective coatings; and readily amenable to biological transformation into many chemicals, gums, and polymers.

The Committee believes that a basic and substantial program should be initiated on the chemistry of sucrose, thereby providing new industrial outlets.

Naval Stores. The Committee recommends that research be expanded and intensified on Naval Stores. Basic research should be undertaken on the chemistry of the pine gums and development research undertaken for chemical modifications which might make the products useful in the manufacture of protective coatings, paper sizing, printing inks, plastics, plasticizers, and pharmaceuticals.

The current heavy supply of naval stores needs new outlets and increased production would be possible if new uses could be conceived. The latter is in itself desirable as complementing reforestation in the Southern States.

Pharmacology. New foods, new processing methods whether or not incorporating additives, changing methods of storing and handling the raw material, and the proposed use of isolates or concentrates of natural constituents have a common prerequisite to safe exploitation. There is need for careful pharmacological and toxicological evaluation. The Committee therefore recommends the continuation and further development of the very important pharmacological work centered in the Western Utilization Research and Development Division and serving all units of Agricultural Research Service. It feels that the problem of toxic microbial products which might contaminate agricultural products should be pursued at the earliest date. Problems should be identified and methods of prevention and control studied.

OILSEEDS

Industrial Utilization of Linseed Oil. Flaxseed faces increasing competition in its principal uses in paint and allied industries, from a wide range of specialized polymers, tailored to specific end uses. Recent and promising applied research on adaptation of linseed oil to water-thinned paints needs continued support to complete their development for, and multi-year evaluation on, exterior wood and other surfaces. This multimillion gallon use needs basic studies in polymerization, pigmentation, and emulsion technology.

Linseed oil protection against freezing and cracking of new and old concrete pavements and structures is a new, promising use which needs further improvements in alkali resistance and general durability. Selective chemical modification of the ester group is a possibility for this.

Difficulties in use, due to phosphatides and other "foots" components, of linseed oil need detailed studies made possible by new, more precise analytical instruments, in the interest of lower cost oil refining, and more durable, more color-retentive paints. Fungus and other microbial degradation of paints is one of the more difficult and important aspects of the very broad problem of preservation of oil based materials. It needs basic research on the biochemistry of the oil decay to point the way to general prevention.

Food and Industrial Uses for Soybean Oil. Soybean oil surpluses warrant continued research to overcome flavor reversion and maintain its position as a food oil. Basic studies on autoxidation of soybean oil and identification of products thereof should benefit both food and industrial uses. The surplus of soybean oil suggests more intensive research through new synthesis toward novel chemical products for industrial use. Oxidative cleavage to yield new commercial sources of aldehydes illustrates the many possibilities of synthesis of components for new and improved plastics, paints, and other commercial products. Exploratory research of this sort deserves latitude of choice of routes toward synthesis.

Feed, Food, and Industrial Uses for Soybean Meal and Protein. Soybean meal continues in high demand as a domestic animal feed, but adaptation to human food to reduce the worldwide shortage of protein needs further research. Modification of this protein by fermentation and other treatments to make foods conforming to customs of various foreign lands should raise the export potential of this important crop. Preservation of flavor and general stabilization of this protein by various means should widen its use for both food and industrial uses. Basic research on the minor components such as enzymes, sterols, etc., toward their more precise identification and control is needed as a foundation for all synthetic work on soybean protein.

Cottonseed Processing and Products. Cottonseed oil and meal are important co-products of cotton fiber and improvements are urgently needed to maintain their position competitive with other oilseeds. More economic removal of the reddish color of cottonseed oil for wider customer appeal demands further research and development. Removal and possible use of the unique cyclopropene acid in cottonseed oil requires new techniques of identification and separation. Toxic components such as gossypol in cottonseed meal and the need for efficient balances of proteins in animal feeds suggests continued basic studies of amino acid components and milling methods for cottonseed meal.

Peanut Processing and Products. Peanuts and derived oil and meal urgently need studies toward mitigation of fungi within the shell and kernel. Identification and measurement of amino acids, flavor, and other normal components, as well as degradation products, are needed to standardize present peanut product quality as well as to point the way to wider utilization in new products.

Tung Processing and Products. Tung oil is a unique oilseed holding a unique, important place in the paint industry. Recent decades of domestic development in the Gulf States deserve continued support in

utilization. The exceptionally durable quality of films from this oil suggest continued support of present work on its incorporation in intumescing, fire-retardant paint. A complete solution to this difficult and complex problem would contribute much toward saving lives and property. The continuing specialization of paint products through use of new, synthetic polymers of high performance suggests the need for preparation of a monograph covering critically and in depth the long developed science and technology of tung oil.

Castor Processing and Products. Castor oil is a unique oil with an increasing number of diverse uses. The growing commercial success of urethane films and foams is a natural end-use for castor oil and needs research and development for new uses and to maintain its position in competition with synthetic polyesters and polyethers. The toxicity of castor meal is a handicap to the cost of the oil as well as to the use of the meal and the processing of both. The current program of identification and assay of allergens is a most important advance in several respects and deserves full support, both for extended use of castor oil and meal and for alleviation of allergies generally.

Safflower Processing and Products. Safflower oil has grown rapidly in recent years in production in several States and promises to be an important crop, adding productivity to semiarid regions of the United States. Its unique high content of linoleic ("polyunsaturated") acid makes it of high interest both as a dietary component and as a vehicle in paints which are whiter than from linseed oil and faster drying than from soybean oil. As with any new, major oil, safflower oil needs study of its detailed properties along with efforts to reduce the hull component in safflower meal and to improve the economy of oil production.

Oilseeds from New Crops. See Utilization Potential of Replacement Crops under NEW AND SPECIAL PLANTS.

POULTRY, DAIRY AND ANIMAL PRODUCTS

Increased consumption of dairy products, poultry, eggs, meat, hides, and animal fats could be achieved through improved quality, lower processing costs, and new product development. These objectives can be attained through utilization research. The Committee recommends that greater emphasis be devoted to utilization research as follows:

1. Meat. To basic research on the chemistry of the proteins comprising the connective tissue with the objectives of increasing understanding and the ultimate control of meat tenderness; to basic research on fat components for increasing understanding of the composition of meat fats necessary for improving the quality and stability of meat and meat products; and to basic microbiological research on meat with the objective of increasing understanding and hence control of microbial growth to prevent spoilage, or enhance desirable properties; to applied research on methods for using edible tissue to form reconstituted new meat products.

2. Milk. To basic research on the chemistry and bacteriology of flavors of dairy products with the objective of improving desirable flavors in fermented products and of improving and stabilizing the flavor of concentrated and dried milks, and to basic research on the composition and structure of the minor components of milk, with the objective of improving the physical and organoleptic properties of processed milk products; to basic and applied chemical and bacteriological research on milk fat with the objective of improving the physical and organoleptic properties of processed milk products; to basic and applied chemical and bacteriological research on milk fat with the objective of enhancing butter flavor and developing new food applications for butter fat.

3. Poultry. To basic and applied research on the chemistry of protein, lipid, and minor components of poultry to provide means for the full utilization of all poultry parts and to provide a better understanding of variations in and control of the flavor, tenderness, and juiciness of poultry processed into existing and newly developed products by such procedures as dehydration, freezing, irradiation, and precooking.

4. Eggs. To basic and applied research on the chemistry of protein and lipid components and on the microbiology of eggs in order to provide a better understanding of changes which take place in various steps of processing to yield egg products which are more convenient, have wider usage, and present no microbiological hazards.

5. Hides. To basic research on the physics and chemistry of hide components, especially collagen and related constituents with the objective of developing leather of greater uniformity for use in automated processes and the objective of developing new and improved leather products.

6. Animal fats. To basic research on composition, structure, and chemical and physical properties of fats and their chemical derivatives with the objective of increasing the industrial utilization of animal fat in such products as polyurethanetype plastics, polymers, lubricants, and biodegradable detergents.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.

REPORT AND RECOMMENDATIONS
of the
UTILIZATION RESEARCH AND DEVELOPMENT ADVISORY COMMITTEE

Developed at its Second Meeting
December 14-17, 1964
San Francisco, California

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Additional copies of this report may be obtained from: Executive Secretary, Utilization Research and Development Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

I. GENERAL COMMENTS AND RECOMMENDATIONS

Long Range Utilization Research Program. The Utilization Research and Development Advisory Committee commends the Department of Agriculture for its leadership in utilization research on farm products and strongly endorses the goals so well set forth by Dr. Nyle C. Brady, Director of Science and Education in his talk before OECD Committee of Agriculture, October 19, 1964.

Present agricultural crops now in excess of current needs are crops well adapted to increased farm production. These and new crops not now widely grown constitute a source of industrial raw material which is replenishable annually and can be tailored to the needs and volume demand of industry.

The Committee believes that utilization research should be planned and implemented for the long-range expansion of the agricultural economy of the Nation.

Basic Research. This Committee observed several instances where recently obtained basic research results are already making important contributions to the solution of problems which heretofore had been unsolved. Therefore it is the recommendation that fundamental or basic research continue to receive the major emphasis it deserves. It is recognized that there is no sharp line of demarcation between basic and applied research. It is felt that Government laboratories should devote the major portion of their resources to basic research and that industry should be encouraged to assume more responsibility for applied research.

Contracts and Grants. The use of contracts and grants to cover some of the badly needed basic studies is a commendable part of the program. The use of Section 32 and Public Law 480 funds for research is also recommended where such funds are available.

Facilities, Instrumentation and Personnel. The Committee was impressed with the excellent staff, fine facilities and broad, comprehensive program of the utilization research work of the Agricultural Research Service and complimented it on its achievements to date in these respects.

The team approach to the solution of problems is a commendable one as it encourages the development of specialized equipment that can be used on a number of commodities being studied at each laboratory. Improved instrumentation and the development of new or improved analytical techniques are essential to progress in utilization research and should be stressed in planning for the future. The investments in this new equipment and in the specially trained personnel required to operate it, and the volume of work required for efficiency in its use, can only be justified in rather large laboratories or aggregations of workers in related lines of endeavor.

In order to facilitate the use of computers as a research tool and to speed up the analysis of the large volumes of data being produced, the Committee recommends that computers be made available locally for each of the main laboratories at the earliest possible date.

Disposal of Agricultural Processing Wastes. As a result of rapid population growth, more housing developments in rural areas, rapid expansion of industry into formerly rural areas, and the expanded use of natural resources for recreational purposes, we are faced with increasing problems of air, soil and water pollution.

All of these categories increase the urgency for immediate research (as recommended by this Committee in 1963) on the properties of agricultural product processing plant waste materials (both liquid and solids) and an economical means of their utilization or disposal.

We urge that H.E.W., in its assigned responsibility in this area, utilize the information already developed by the Utilization Research divisions of ARS and other agencies. It is recommended that a practical program be developed with the immediate establishment of specific liaison between U.S.D.A. and H.E.W.

Coordination of Research, Dissemination of Results, and Information Retrieval are interrelated tasks which grow even faster than the growth of research. It is noted that:

1. Much of the Department's utilization work is decentralized according to geographic and administrative needs;

2. Departmental executives carefully coordinate work between separate locations and avoid duplication, since they continually and closely monitor all such work;

3. All results are ultimately available on the two broad levels of publication by the Department and in such exhaustive indices as Chemical Abstracts;

4. Wholly new publications should not be added hastily to the huge array of scientific periodicals already extant;

5. There is a practical need to supply potential users of this research with consolidated presentations of broad areas of the Department's research work, for example, (1) textile fibers, (2) fatty oils and acids, (3) proteins and amino acids, (4) sugars, starches and other polysaccharides, (5) pharmacology, (6) analytical methods and instrumentation.

It is therefore requested that ARS seek new or better methods of bringing to the attention of those in industry, who are likely to initiate conversion of the knowledge into commercial process and product growth, the progress of R & D at early stages of the work. These reports may be in the form of draft or information memoranda distributed to advisory committee members and industrial development administrators.

Pest Control Problems. The Committee sees in the pharmacological work, which serves all Utilization Divisions together with some other ARS groups and embraces toxicology, pharmacodynamics and allergy, a very effective program to safeguard the wholesomeness of foods. The program is both basic and realistic. Two important related areas require attention, whether in Utilization or some other part of Agricultural Research Service.

First is the question of the significance, analytically and physiologically, of pesticides which may be indicated as present but at such low levels as to be confused with the same or similar naturally present "background" material. Until this question is resolved, especially with regard to the "zero tolerance" chemicals, quality control and legal compliance lack precision which must serve as a guide to good production practice.

Second is the need of a provision for rapidly developing information to clear new methods of biologically controlling agricultural pests.

In view of the importance of developing biological control measures for agricultural crop and animal pests, the Committee recommends that the U.S.D.A. make maximum use of its available facilities for obtaining at the earliest date all information needed for presentation to F & D for clearance of biological control agents.

This area of controls has already been designated as a "Top Priority" item by the Secretary of Agriculture--and time is of the essence.

Analytical Methods and Instrumentation. Compositional studies have already served many of the commodities in extending their utilization and this program should continue, with due attention being given to genetic and environmental factors.

Related to the collection of compositional data, the Committee pointed to the need for analytical methods and definitive specifications accurately describing certain of the constituents with which we are concerned. The analytical methods should be, wherever possible, objective, reproducible, rapid and precise. Examples of such analytical methodology needs include xanthophylls in food products, feeds and forage; limonin, limonoids and other bitter principles of navel orange to follow debittering processes; fatty acid compositions of oils and fats; amino acid composition of proteins and peptides; rapid and accurate methods for vitamin assays for all known vitamins; identification and estimation of alkaloids, etc.

Odor and Flavor Fundamentals. Because of the extreme importance of acceptable flavor as a factor in the utilization and consumption of all food products, it is recommended that the basic and fundamental flavor studies on all commodities be carefully correlated. Basic flavor research, including research on objective methods for determining flavor components, should be emphasized and strengthened.

Retraining. The need for more and better trained manpower for utilization research appears to be one of the critical challenges for the future. The utilization laboratories now have an excellent core of highly trained and experienced scientists. However, like many other organizations there is a large number of competent technologists who could benefit from further scientific training at the postgraduate level. This training would prepare the scientist to participate in a wider scope of research in his specialty and in related fields, as well as accept leadership responsibility which will be increasingly demanded in the utilization research of the future.

It is the recommendation of the Committee that the Department expand its program of retraining at the postgraduate and postdoctoral levels for promising and competent staff scientists.

II. COMMENTS AND RECOMMENDATIONS ON CURRENT AND NEEDED RESEARCH

In recommending new or expanded research on problems listed in this section, the Committee recognizes that it is not its responsibility to delineate between research to be conducted within the Department and that to be conducted in cooperation with State Agricultural Experiment Stations and other research organizations. The recommendations made by the Committee are based on their judgment that the problems are important and that research is needed. The Committee did not establish any priorities as to importance of problems recommended.

CEREAL AND FORAGE CROPS

Industrial Utilization of Cereal Starches. The Committee recommends increased emphasis on fundamental research with cereal starches. It is felt that utilization would be enhanced by a better understanding of starch granule structure, and undoubtedly this will require a more complete understanding of molecular structure and chemical reactions of starch. It would also be of value to learn more about the role, and the locus of the non-carbohydrate constituents. Such fundamental information will undoubtedly pave the way for the needed new knowledge to facilitate the plasticization of starch films.

The Xanthide work is most valuable. Much of its further development probably could be left to the paper industry. Ex situ xanthides, and graft polymerization, however, are not that far advanced, and should continue to receive a considerable amount of attention.

Starch derivatives as protective colloids, and halogenated starch derivatives are of less immediate interest or importance. Yet this is the type of research the Department is urged to conduct.

Industrial Utilization of Wheat. The Committee subscribes wholeheartedly to basic and exploratory research on wheat fractions. It feels, however, that this should be heavily weighted toward the protein fraction in which wheat is truly unique including fractionation and characterization of the fractions. The proposed studies on the interaction of starch and protein

open an interesting area and probably is worth exploring. It fails to see where the diversion of one surplus crop such as wheat into markets traditionally supplied by another crop, also in surplus, is the best use of utilization research funds. If such research will lead to products having unique properties not found in existing industrial materials derived from agricultural sources, then such research does definitely have a place in the utilization research program.

The Committee is gratified to note that the recommendations of the 1963 Committee have been largely accepted and will be largely followed through F.Y. 1966. The Committee doubts the economic feasibility of the acid modification of wheat flour for use as a surface-sizing agent for paper, at least to any great extent, but it is probable the methods being developed will apply equally well to prime starch; therefore the Committee recommends continuation of the project.

Expanded basic chemical, enzymatic and histological research is needed to understand the microscopic and submicroscopic structure of the endosperm and the interrelationships of the starch, protein and lipid as a basis for the development of better milling and air classification techniques.

Corn, Sorghum, and Other Feed Grains. Fundamental information on composition and compositional changes that occur in processing of corn, sorghum, and other feed grains are needed areas for research under the utilization research program. In general we feel that research on this project and in this general area is insufficient in proportion to its importance, and we recommend intensification.

Research on new human food products from corn and sorghum flours is a good area for investigation and should be initiated. This was recommended in 1963 but has not been activated.

High Amylose Corn. High amylose corn has been custom-developed to fill an anticipated industrial need for a starch-bearing crop suitable for producing films and fibers. The breeding program has been going well, but it requires much analytical support to keep it oriented. Unexpectedly it has also been found that both the amylose and the amylopectin fractions are substantially different from those of conventional grain and may necessitate special treatments. Both fundamental and applied research are still sorely needed in this area. This new corn product also requires special new milling techniques which need further research.

Fermentation of Cereal Grain Products. Our vast annual production of starches gives us a most attractive source of fermentable carbohydrates, and fermentation as a unit process provides a highly flexible method of converting this storehouse into a host of new and useful products. The Department has, at the Northern Utilization Research and Development Division, exceptionally fine facilities and personnel to exploit this almost untapped area. It has been traditional for the USDA to work in this area, it has proven most fruitful through the years, and it should be expanded to as high a rate as can be afforded. The plans for F.Y. 1965 to 1966 appear sound and well conceived.

Food and Feed Products from Wheat and Barley. It is urged that the work on chemical composition and physical properties of wheat and barley be accelerated to provide the basic information on which new and better food and feed products can be developed.

The work on new and improved wheat foods should be directed toward unique foods; process development work should be carried only to the point where it can be picked up by industry. The new WURLD wheat product looks very promising and appears to have commercial potential.

Rice Processing and Products. The program on basic chemical composition and physical properties should be stepped up as much as possible. The Committee recommends that the Southern and Western Laboratories work on their respective investigations with pure strains of seed of known history from three leading varieties of rice simultaneously. It is felt that the simultaneous study of the three varieties with greatly different gross cooking qualities will produce data which will be more useful sooner, than if only one variety is chosen.

Information is coming forth from the "deep milling" studies on the differences in chemical composition and cooking quality of white rice milled to various degrees. This could be compared to parboiled rice processed and milled to various degrees.

In addition to the studies on chemical and physical composition of raw rice, there is need for detailed study of the changes which take place during cooking, with emphasis on histological and histochemical techniques which will reveal the in situ changes.

Work on the high protein rice flours and air classification techniques should be expanded to produce special purpose flours. The rice-milling industry also needs research help in machine design to provide more sophisticated mills for the finer milling cuts indicated.

Microbiological studies similar to those on other cereal flours should be made since rice flour is potentially useful in many specialized food products where low microbial contamination is required.

It is recommended that a continuing program be initiated (possibly with P.L. 480 funds) whereby the Oriental and Indian literature on rice research is surveyed and detailed abstracts of important advances are translated for distribution to U. S. cereal chemists. It is suggested that the Department might initiate (also with P. L. 480 funds) a research program on the genetic improvement of the protein content of rice, both as to quantity and quality (still further improvement in lysine and methionine). This would parallel the work on deep milling.

Forages and Feed--Processing and Products. The good work on the isolation and study of biological activity of both beneficial and toxic substances from feed and forage materials should be expanded so that ways and means of retaining the maximum amounts of beneficial nutrients and eliminating the adverse substances can be developed. Work should be continued on basic compositional studies and the correlation of composition with nutritional qualities.

Roughage feeding could be more effectively and efficiently handled if more were known about the digestibility, and the fate of both hemicelluloses and lignin not only in ruminants but also in short-gutted animals.

COTTON, WOOL, AND OTHER FIBERS

Chemical Composition and Physical Properties of Wool and Mohair. The basic investigations into the structure of the wool fiber should be continued and in addition should be extended to include knowledge of the effects of chemical processing and new fiber modifications on the fiber use attributes of wool in fabrics and garments.

New and Improved Textile Products and Processing Technology of Wool. Studies should be expanded on the effects of chemical and mechanical processes on various methods of attaining set and maximum recovery in wool fabrics which have been designed for attributes of maximum recovery following elongation in use.

Applied research should be strengthened on developing pilot plant processes which demonstrate possible commercial equipment and processes which give maximum stretch recovery to wool fabrics.

Research should be expanded to develop methods of imparting resistance to insect attack, soil and spot resistance, wrinkle recovery and other attributes giving improved fabric performance and appearance retention.

The mohair fiber should be studied and processes developed for modifying it morphologically or chemically to increase its utility in blends with wool and other fibers in conventional woven and knit fabrics manufactured by conventional wool yarn and fabric processes.

It is advisable to shift active development effort of WURLAN processes for fabrics to commercial process development of WURLAN treatment of scoured wool for yarns spun on woolen yarn systems. The commercialization of WURLAN processes on wool fabrics and wool top should make this shift of assigned development effort possible.

It is recommended that wool fibers which have been modified by the various chemical and physical processes by means of which new use attributes have resulted in fiber performance be studied as to their performance not only in fabrics using 100% wool fibers but in yarns and fabrics made up of blends of these modified wool fibers with cotton fibers and synthetic fibers. An example might be a blend of these modified wool fibers with cross-linked or resin treated cotton fibers to determine if a completely washable no-iron garment can be achieved from a blend of the two fibers.

General Recommendations on Cotton. The competition of synthetic fibers for cotton and wool markets has attained a significant level and represents a serious threat to further consumption of natural fibers. Heretofore, a policy of research on natural fibers only has prevailed and government utilization laboratories have not investigated blends of fibers.

It is suggested that research be originated in blends of natural and synthetic fibers with the objective of becoming acquainted with the basic qualities of synthetic fibers alone and in cotton blends. This education is necessary as a basis for further, more intelligent investigations of chemical modifications of cotton.

Attempts should be made to duplicate the performance of blends using only natural fibers, blends of natural fibers and blends of chemically modified natural fibers.

Basic and Exploratory Investigations on Cotton. The SURDD has come to be recognized for their investigations of gross structure and morphology of the cotton fiber; for their elucidation of chemical and physical behavior after exposure to various mechanical or chemical treatments. Continued emphasis and expansion is recommended for this area , for it is through these basic studies that the eventual solving of the major problems at hand and those problems which will occur as textile technology and synthetic fiber competition develop further.

It is recommended that exploratory chemical research be initiated into the investigation of cross-linkable cellulosic films, coated on the surface of the cotton fiber. For all intents and purposes, the cotton fiber itself will remain chemically unchanged. Under this same category, cross-linkable polyester coatings should be investigated and is used only to illustrate the wide range of possibilities.

Emphasis should be placed on feasibility studies of promising exploratory chemical and physical investigations. Expanded bench scale development is a requirement for accurate prediction of commercial possibility.

Interrelations Among Fibers, Yarns and Fabric Properties of Cotton. The recent developments in machinery in which higher speeds are the rule and the prospect that processing speeds will continue to increase, make it important that knowledge of the optimum processing organizations for various types of cotton fibers and various yarn and cloth structures be available to the industry.

With the advent of the concept of "total washability" in garments, it is imperative that more information of structure of yarn and fabric be developed. It is with a number of small advantages gained from each of several areas including fabric construction that a superior all-cotton washable garment can be visualized and commercialized.

One of the prime needs of the industry is the ability to evaluate the potential spinning and processing value of a cotton before it is purchased. The Committee thoroughly approves expanded work in the field of accurate measurements of cotton properties.

New and Improved Cotton Textile Machinery. The Committee wishes to re-emphasize that in the field of machinery development major efforts should be directed toward radical new approaches, minimizing work on the improvement of conventional and existing machinery. The current contract work on aerodynamic and electrostatic approaches to cleaning and opening cotton are excellent examples of this type of work.

The present work on the removal of short fibers should be expanded as higher processing speeds make this essential. Inasmuch as there are four commercial automatic opening and blending systems and several others in the prototype stage, the advisability of further work on the opener-blender is questionable. The long-range emphasis on scientific developments of new methods for converting cotton fibers into textile products is commendable.

Developments of new and improved processing machinery, drawing through weaving, should be undertaken only after a thorough analysis of the basic problems in these areas which are caused by cotton's peculiar physical characteristics, so that work may be directed toward developments which will be of peculiar benefit to cotton processors.

The project for super-cleaning of cotton for use in products which do not require spinning should explore chemical as well as mechanical means to attain this end.

Improvement of Wash-Wear Properties of Cotton Fabrics. Inasmuch as recent developments in this field have expanded far beyond the original concept of Wash-Wear, this area should be designated by the concept of "Total Garment Washability." Total garment washability should denote and encompass, permanent pleats, smooth drying fabric body, delayed cure if required, non-seam puckering, and washable garment findings.

At this time, multi-purpose finishing in the sense of deliberately combined water repelancy with smooth drying, etc., should be de-emphasized in favor of concentration on the single attribute of smooth drying in approved fabric.

Abrasion is the most outstanding problem with "Total Garment Washability." The present program of investigation of durable polymeric coatings is applauded.

Smooth-drying properties without actual cross-linking should be emphasized.

"Another" delayed cure process cannot be justified unless there is potential for demonstration of improved physical properties.

Before work on swelling pretreatments is terminated, we recommend that the optimum dry to wet crease-recovery ratio for optimum performance under both line drying and tumble drying conditions be determined.

Cotton Products with Special Properties. To "catch up" with the synthetics stretch market, intensified further research in the area of slack mercerization, as well as the use of resin treated, back-twisted stretch yarns is needed.

Another area that has recently become urgent is that of flame resistance. A very low cost finish which can be applied on conventional continuous finishing machines is badly needed.

Although great work has been done in the field of weather and rot resistance, still more work is needed to combat the competition from synthetics.

The work in progress on soil resistant finished should be expanded.

A study on luster should be directed towards possible physical modifications through changes in fabric design and through finishing processes, either mechanical or chemical. Luster changes should be low-cost, probably no more than the cost for mercerizing fabric.

The concept of obtaining color effects by blending chemically modified cotton (with different dyeability) with raw cotton should be considered. For instance, acetylated cotton, aminized cotton, etc., could be considered. These chemically modified cottons should have the quality of low cost and stability to dyeing chemicals such as vat dyes.

Relative to the problem of abrasion, in addition to those efforts underway or contemplated, the idea of developing a "Nylonized" cotton or a "Polyesterized" cotton for blending is of great interest. It may be possible that some type of chemical treatment would impart strongly abrasion-resistant properties to cotton. The treatment could be imparted to raw fiber, the treated fiber blended with raw fiber in appropriate amounts.

FRUIT, VEGETABLES AND SUGAR

Compositional Studies of Fruits and Vegetables. Common to the problems in processing all fruits, vegetables, and tree nuts is the matter of maintaining and improving the qualities of flavor, appearance, and texture. In many instances these characteristics are influenced by the effects of mechanical harvesting. Increasing knowledge of the basic constituents resulting from compositional studies of many of these commodities is making the task of solving these problems easier by research workers of both USDA and industry. Such compositional information, depending on the nature of the food product, contributes to the solution of the problems of

preserving or enhancing the natural flavor and preventing off-flavor, preserving natural color or preventing darkening, stabilizing natural cloud in a liquid or accomplishing its clarification or of maintaining desirable texture. The Committee recommends the continuation of compositional research at an increased level of support.

As the basic compositional data indicate, the solution of practical problems of color, flavor, and texture should be sought by research on the important varieties of the species in the several important U. S. producing areas for the species.

Microbial Spoilage of Fruits and Vegetables. Processors of fruits, vegetables, and tree nuts encounter considerable losses through microbial deterioration and spoilage. Research on this subject and on the biochemistry of the bacterial spores is of direct interest to the industry. Therefore, the Committee favors increased support for this research at the appropriate laboratories.

Sugar Producing Crops. The Department of Agriculture in carrying out its responsibilities in maintaining an adequate supply of sugar at stable prices has found it necessary to reduce domestic production in 1965. Unfortunately, this follows a request made to the domestic beet and cane sugar growers and processors less than two years ago to effect a rapid expansion to offset a sugar shortage. The response of the industry to this request was immediate, and an increase in sugar production has resulted. The current cut-back in production further jeopardizes a domestic industry already beset by serious problems in economical recovery of sugar and possible loss of certain markets to synthetic sweeteners. The Committee recommends that increased research effort go into the area of sugar producing crops to assist in the solution of these problems.

The general organization of the research program is suitable. However, chemical composition studies should be increased to include the quantities of non-sucrose components which originate with the crop and how these are affected by the conventional processing procedures. In the case of sugar beets, this should include a continuation and expansion of the compositional studies of changes occurring during post-harvest storage.

Research should be expanded to correlate the composition with processing quality to provide guidelines for new processes and varieties aimed at improving the economics of sugar recovery. Possible new and useful by-products should be investigated to assist in this endeavor.

Studies in sucrochemistry should be resumed and expanded in search of useful products to provide non-food uses for sucrose.

OILSEEDS AND SPECIAL CROPS

Flaxseed--Industrial Utilization of Linseed Oil. The present work on use of linseed oil in protective coatings for concrete pavement and other structures, and on water reducible, exterior paints is commendable and should be continued, with emphasis on basic reactions and mechanisms rather than detailed formulations. Basic reactions particularly adaptable to linseed oil should be studied. Among these are vinylation, e.g., by acrylonitrile, conjugation via new, more selective catalysts or any other means of utilizing the high unsaturation of this oil, while diminishing in a dried film thereof their continued reactivity and ultimate degradation. Microbiological staining and degradation of paints based on linseed and other fatty oils continues to be a major deterrent to their continued or increased use. New approaches should be sought to combat this problem, either through modification of the oil itself or by new and permanent additives such as organic or metalloorganic biocides. At the same time, more detailed information is needed on the nature and possible suppression of chemical degradation of films from drying oils, whether by oxidation, hydrolysis, saponification or otherwise.

Food and Industrial Uses for Soybean Oil. The expansion of current markets and the development of new markets for soybean oil are of fundamental importance for increasing soybean production in a profitable manner. Therefore, the Committee recommends that research on the enhancement of soybean oil as a food oil, for foreign and domestic use, and on the development of new industrial uses for soybean oil be expanded. In particular, this work should include those basic and applied studies which may result in a practical method for the production of an edible soybean oil having improved stability both in storage and use. Also, investigation of the chemical modification of soybean oil with a view toward the preparation of novel and industrially useful derivatives should be continued with both basic and necessary applied studies.

Feed, Food and Industrial Uses of Soybean Meal and Protein. Fundamental investigations on the physical, chemical and physiological or biological properties in relation to the molecular structure of major and minor soybean meal and protein constituents are needed for improved utilization in feed, food and industrial use. These investigations should encompass the changes in molecular structure and associated properties that arise during utilization processing. For the development of food protein ingredients having acceptability in a wide variety of food items, both domestic and foreign, basic and applied studies on the characterization, and alteration or elimination of undesirable flavor or flavor precursors, color and physiologically active components should be expanded. Research on the elaboration of mycotoxins by the growth of field and storage fungi on soybean substrates should be stressed since this has serious implications in the feed and food utilization of soybean meal products.

Cottonseed Processing and Products. The oil and meal from the cottonseed are important products of the cotton economy and to maintain their present position and open new markets the following research and development activities are indicated: (1) Methods of economical removal or inactivation of cyclopropenoid components and exploration of the use of such substances as starting materials in polymer and related fields; (2) the search for and elimination of mycotoxins and methods of preventing their appearance in cottonseed products; (3) continued study of gossypol removal or inactivation and of other color forming substances or toxic substances in existing and possible new varieties of cotton; (4) study of the cottonseed components with the objective of producing products which can be used for improved feeds, foods, and industrial products; (5) investigations of the pharmacology of gossypol, cyclopropenoid substances, and of mycotoxins found in cottonseed.

Peanut Processing and Products. The occasional presence of mycotoxins in peanuts and peanut products requires continued study as to simple methods of detection and measurement of amount, the nature of the toxin(s), their origin, pharmacology and means of preventing their appearance in the peanut. Economical means of decontaminating affected product or alternative uses of contaminated product(s) deserves study. Investigation of proteins, flavor substances and other components of the peanut are needed to associate objective measurements with quality. Uniformly acceptable products and development of new products, which could expand utilization of this crop, logically follow the identification and quantitative isolation and characterization of the important components.

Tung Processing and Products. Recent investigations of tung oil in paints having both fire retardance and exterior durability is commendable. Continued work in this area is desirable because of widespread needs for fire retardant paints in both civilian and military use, because of the complex details of meaningful fire tests and of the numerous agencies concerned with levels of acceptance. The unique chemical nature of tung oil deserves a continuing program of basic research to develop unusual and useful reaction products to supplement the long established uses which suffer economic competition by various synthetic materials.

Castor oil continues to grow in importance as a domestic oil, even without price support, and its present, continued domestic growth on increasing acreage should be encouraged through research on its problems. Whereas castor oil has established uses, the residual castor meal continues to be a major problem. The excellent work done on detection of allergens should be extended toward chemical identification of their components, and this knowledge used to make detection simple enough and reliable enough for commercial manufacturing control. Further studies are needed on carbohydrate and protein composition of the meal which should lead to more satisfactory feed use. Basic chemical studies of castor oil's unique reactions should be expanded, illustrated by good work already performed in producing 12-ketostearic acid. Derivatives such as phosphates, halides, urethanes and others should be studied with respect to reaction conditions and yields while leaving mostly to industry the extension of these products into a proliferation of formulated uses such as plasticizers, foam coatings, etc.

Safflower Processing and Products work should be funded to utilize the current developments of new species with respect to: (1) still higher linoleic acid content, (2) conversely higher oleic acid content, and (3) lower hull content. Each of these improvements can lead to non-competitive utilization of dry lands and production of unique food, feed and industrial values. Efforts to attain still higher content of linoleic acid, and still lower content of saturated acids should be made in the interest of developing alkyd or other polymers which are more uniform in properties to compete with synthetic polymers made from commercially pure monomers.

Naval Stores Processing and Products deserve expanded support against competition from synthetic materials, and to make highest use of the unique chemical compounds available in naval stores. Recent work on photochemical production of peroxides from pine gum and on production of a hydroxy derivative of rosin acids by addition of formaldehyde, are illustrative of the possibilities of exploratory research in this area of organic synthesis. Further avenues of chemical synthesis based on naval stores components should be explored.

Pharmacology. In view of recent experience with mycotoxins, pesticide residues and naturally occurring toxic substances, the further development of the pharmacology area is essential to the utilization research and development program. Investigations of the pharmacodynamics, pathological, physiological and toxicological effects of intentional additives, residues and contaminants, mycotoxins and naturally occurring toxic substances are required in several geographic areas and in a variety of products which are under study in various laboratories. It is recommended that this area be expanded to adequately serve the presently acute and future problems that arise in utilization studies.

Utilization Potential of Replacement Crops. The search for new and development of agronomically suitable replacement crops containing unique components having industrially useful properties is worthwhile for the long-range health of our agricultural economy and thus should be continued. These potentially useful components include oils of unusual structure and properties, new mucilages and gums, protein with novel properties, fibers of potential value for pulp, paper, structural board and the like, among others. Attention should be focused on those crops having components differing in composition and/or properties from those present in current domestic crops.

Further developmental research on processing and industrial application should be carried out on agronomically adaptable seeds which contain oil of unusual fatty acid composition such as (1) crambe abyssinica, (2) vernonia anthelmentica, (3) Limnanthes, (4) Cuphea, and (5) Umbelliferae. The Committee considers that the economic utilization of by-product and processing residues is a part of these developmental studies and should be initiated when progress in application work and agronomic adaptability warrent.

Tobacco. As with most natural products, tobacco needs to be thoroughly investigated with modern scientific methods and tools. In view of recent questions concerning tobacco usage and health and the great economic stake of the growers, the industry and the government, a considerably expanded program of research is needed. Specifically, increased effort should include: (1) isolation and identification of the chemical components of tobacco leaf and smoke therefrom--including low level components which determine flavor, or which may arise from residues of applied substances such as pesticides; (2) the identification of leaf constituents which are precursors of specific smoke components; (3) the study of specific leaf constituents as related to agronomic practices and treatment of the harvested product; (4) the effects and factors contributing to or inhibiting of ageing of fermented and non-fermented tobaccos; (5) the basic physico-chemistry of the smoke-forming process; and (6) the coordination of the above with related investigations in industrial laboratories and with investigations concerning the tobacco-health question.

Maple Sap and Sirup. Further studies are needed to determine economical means, such as adapting idle food processing plants, for processing sap under optimal conditions for developing a superior product. This would include investigation of modifying agents which contribute to better process control, such as sugar-sanding, to improved flavor development and to better preservation qualities. There is need to determine the essential flavor components and the effect of processing variables on these if superior flavor qualities are to be retained and reasonable uniformity as to flavor achieved.

Honey Processing variables and improved equipment studies are needed in order to assure optimum conditions for preservation of flavor and to control enzyme changes that occur during the processing.

POULTRY, DAIRY AND ANIMAL PRODUCTS

Greater emphasis must be given to utilization research, particularly fundamental research needed to furnish the basic information required for technological improvements in the utilization of animal and poultry products.

1. Meat. During the past year, research on meat has been expanded in most of the areas recommended by the Utilization Research and Development Advisory Committee last year. However, because of the great need for basic information, the Committee recommends further expansion of the research programs on meat composition and quality and on meat flavor. Additional emphasis should be placed on fundamental studies of meat proteins, meat flavor, and meat color. The Committee suggests that close liaison be maintained with other governmental agencies performing microbiological research.

More specifically, the Committee recommends that the research on meat flavor include investigation of the nature of the undesirable "warmed over" flavor of many processed meat products and elaboration of techniques needed to eliminate or reduce this; that the studies on reconstituted meat products be specifically oriented toward developing the basic information

needed to reassemble large cuts of meat from smaller, but discrete, pieces such as individual muscles, strips or cubes; that the principles of "explosion puffing" be tested for possible applicability to the dehydration of meat and/or meat products.

2. Milk. During the past year, increased emphasis has been placed on chemical and bacteriological research relating to flavor of dairy products. In this area, the proposed contract on genetics of lactic-acid forming bacteria and the proposed grant to study lactones should be executed without delay.

It would appear that many of the technological problems impeding success of many of the concentrated milk products (fluids and dry), are related to a lack of understanding of the physical-chemical behavior of proteins during processing and storage. The Committee recommends that the several groups, now working in milk proteins investigations, intensify their efforts in the basic aspects of protein composition, distribution, and behavior.

Although some increased emphasis has been given to basic and applied chemical and bacteriological research on milk fat and on butter, additional emphasis should be placed on research in these areas to improve quality and stability in these products. The Committee repeats its recommendation of last year that increased emphasis be given to basic research on the composition and structure of minor components of milk. Certainly research is needed on procedures that result in greater uniformity of cheese flavor. The Committee agrees that research is needed on improved processing procedures to maintain flavor in butter and butter oil and on improved processing procedures for heating, concentrating, drying or sterilizing of milk for concentrates production. If these studies are initiated, they should be closely integrated with the more fundamental investigations on chemical, physical and bacteriological properties of milk and milk constituents. It is recommended that modest studies on uses for whey and lactose be initiated at this time.

In view of growing need for flavor investigations in all areas of milk product investigations, the Committee recommends that the manpower (PMY) in the Milk Flavor Investigations section be brought up to authorized strength and increased somewhat so as to more adequately cover the basic and applied phases of flavor problems.

3. Poultry. The Committee recognizes the outstanding contributions made through utilization research by the Department. Results of basic and applied research have contributed to more effective processing, improvement of quality and development of new products. The results of these investigations have helped to maintain a high level of poultry consumption and use of additional grains in the production of poultry.

Investigations designed to improve plant processes and handling relating to dispatching, defeathering, eviscerating, disjointing, chilling, grading, packaging, and transporting are encouraged. Continued emphasis should be placed on studies concerned with the chemistry of proteins, lipids and

minor tissue components to provide a means for the full utilization of all poultry parts and their use in a variety of foods designed specially for convenience of consumers and to provide a better understanding of factors responsible for, and the control of, flavors, tenderness, juiciness and general acceptance of poultry products. It must be recognized that both ante-mortem and postmortem factors influence quality. The handling of poultry on the farms to an important degree determines postmortem quality. Information is needed that will make it possible to decrease the incidence of breast blisters, flesh bruises, skin blemishes, and other grade and quality lowering defects. Achievement of these goals coupled with improved keeping quality and tenderness will help to further increase poultry consumption.

Basic research on factors that influence quality of freeze dried poultry should be expanded. Research on precooking and factors influencing the quality of precooked poultry meat should be expanded.

The importance of studies on microbial spoilage and public health hazards is recognized. Research in this area should be coordinated with work already underway in other laboratories.

The Committee suggests the following problems also be given increased consideration:

a. The development of an acceptable additive that would impart a chicken flavor would be helpful in improving flavors of many convenience products.

b. Develop information that would permit the production of least cost raw poultry meat chunks or pieces free of bone.

c. Develop an acceptable additive that will permit or cause poultry chunks or pieces to become firmly bonded together when fabricating or manufacturing convenience products.

4. Eggs. The Department is to be commended for the outstanding contributions to research designed to promote the increased utilization of eggs. It is especially gratifying that this has been accomplished through a sound program of grant and contract research. The plans for use of current resources are very good. The Committee agrees that additional research is needed in the area of egg protein characteristics and on the modification of egg constituents as a basis for the development of improved egg products to meet specific needs. Such research should be activated as rapidly as funds and personnel become available. Studies should be expanded relating to the effective control or elimination of undesirable micro-organisms from eggs and egg products.

The Committee suggests several areas where research is needed to develop information leading to increased utilization of eggs:

a. The egg industry is faced with declining per capita consumption. A survey is recommended to determine to what extent reduced consumption is due to health scares, competition from other foods, coffee-only breakfasts, inconvenience of cooking eggs, or to the lack of egg quality. This information will be helpful in formulating a program of research that will increase egg consumption.

b. Since successful utilization research leading to new processes and products depends to a large extent on the quality of shell eggs, it is recommended that studies be initiated to determine the factors that are responsible for quality changes that occur during the movement of shell eggs through distribution channels to processing centers. Such studies should include investigation of methods for reducing losses caused by checks and cracks that occur during washing, grading, packing, transporting and processing.

c. Hard-cooked eggs with shells removed are used extensively by consumers, hotels, restaurants, and institutions. Investigations are encouraged that would develop technology necessary to permit the handling of shellless eggs on a commercial scale. This involves development of an inexpensive method for removal of shells, conducting keeping quality studies and selection of suitable packaging methods.

d. Research is needed to develop new egg products that would find ready acceptance as components for preparation of the "main" meal.

5. Hides. The Committee reiterates the recommendations of the 1963 Committee. It is recommended that studies on hides and skins be expanded, with special emphasis on chemical and physical studies on collagen and other connective tissue components. It is further recommended that the collagen reconstitution studies include investigation on factors influencing reconstitution of collagen from other sources as well as from hides.

6. Animal Fats. The Committee reiterates the recommendations made by the Committee last year that the program be expanded. It is urged that the fundamental studies on fat composition and properties be directed toward and correlated with the application studies as rapidly as possible. Careful and specific evaluation of properties and composition should be made with the ultimate goal of effective utilization of specific fats and fat derivatives for food and non-food uses.

UNITED STATES DEPARTMENT OF AGRICULTURE
Research Program Development and Evaluation Staff
Washington, D. C.

REPORT AND RECOMMENDATIONS
of the
UTILIZATION RESEARCH AND DEVELOPMENT ADVISORY COMMITTEE
Developed at its Third Meeting
January 17-21, 1966
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Additional copies of this report may be requested from David J. Ward, Executive Secretary, Utilization Research and Development Advisory Committee, Research Program Development and Evaluation Staff, U.S. Department of Agriculture, Washington, D. C. 20250

PREFACE

The Committee reviewed the Department's cooperative program of utilization research and development. It considered annual Progress Reports and other resource materials describing research activities. National research leaders briefly described research and development programs, discussed some accomplishments and defined important needs. Scientists of the Southern Utilization Research and Development Division gave some on-site demonstrations of procedures, achievements, facilities and problems yet to be solved.

Dr. G. L. Mehren, Assistant Secretary and Acting Director of Science and Education, is Chairman of the Committee. Dr. F. R. Senti, Deputy Administrator for Utilization and Development, Agricultural Research Service, is Vice-Chairman.

Benjamin Phillips was unable to attend the meeting.

I N D E X

GENERAL COMMENTS

The abundance of food and fiber in the United States has been made possible because of research, a favorable climatic environment, American ingenuity and determination, and an opportunity to operate in a country where initiative is recognized. At present we have the capacity to produce more of some agricultural commodities than we use in the normal course of events. Utilization type research is necessary to find new uses for these agricultural products. However, utilization research has far more importance than this in that results of investigations permit the transformation of raw agricultural products into items that will serve the future needs and values of the American people at the local, national, and international level.

The ever increasing population of this country and the world, with concentrations in more densely populated areas, create demands for processing, packaging, and forms of foods which will permit them to be transported to the market place in desirable form and conditions.

Utilization research is of prime importance in meeting these requirements. The report of this Committee points up the need in many of these areas, with the inescapable conclusion that in spite of the savings effected by the termination of certain projects, total investment in the area of utilization research must be increased (a) to maintain present levels of effort because of increasing costs, and (b) to meet the ever-increasing demands on American agriculture.

Long Range Utilization Research Program

The Department of Agriculture and the State agricultural experiment stations are commended for undertaking a long-range study of agricultural research. The results of this study should provide a valuable outline of the nation's needs in utilization research and development and lead to more efficient planning. The Committee believes that the study can provide the framework for future studies of this nature, which must be made periodically to evaluate the agricultural research program.

Evaluation of Research

Agricultural research is an investment in the future of the industry; investment of money, facilities--both space and physical tools-- and most important, of manpower-time, energies, and ideas. As an investment, research must compete with alternate needs for all of these resources. This calls for both careful planning of research programs and frequent and thorough evaluation of projects under those programs. The Department is to be commended for originating and implementing the program of reviews by and for research advisory committees for many years.

The Secretary's Memorandum No. 1589 directs a further comprehensive review of all programs in the Department, including research. This directive will bring into sharp focus the program objectives, and an evaluation of projects in the light of their contributions toward the attainment of those objectives.

This is a commendable approach, and one that should result in renewed enthusiasm and dedication. However, when research programs are reviewed in this context, adequate criteria must be developed for the proper evaluation of basic research. No dollar value can be assigned to true basic research. As pointed out above, basic research provides the foundation for future progress, and this cannot be short-changed in the interest of immediate economies. Time in research, once lost, cannot be regained; neither can time lost in aimless research. Therefore, an evaluation program of this type, properly executed, can be of inestimable value. Conversely, irreparable damage can be done by either inadequate or shallow appraisals.

One of the most difficult problems in the administration of research programs, whether they be industrial, university, or governmental, is the intelligent decision for the termination of research programs or projects. Projects should be reviewed and evaluated at critical points in their progress to determine whether they should be (a) continued under existing levels of effort and expenditure, (b) accelerated, or (c) terminated.

As a general rule, utilization research projects should be terminated when the results have reached the point of possible use by industry or when careful evaluation by staff and industry indicates that the approach or solution is not satisfactory for commercial development. Indefinite continuation of a project is frustrating to the researcher, causes loss of confidence in the program, and obviously is a waste of time and money, both of which are in critical need in other areas. While general performance in the evaluation of projects appears to be good, more detailed reviews are recommended.

Coordination of Research, Dissemination of Results, and Information Retrieval

Coordination of research is essential to expediting programs and preventing unnecessary duplication of effort. The Committee commends the Department and, in particular, the Regional Laboratories for their policies in this regard.

Information retrieval is important, and the efforts of the Department toward improved techniques in this area are encouraged and commended. However, the Committee recommends careful evaluation of these procedures from the standpoint of need and efficiency before they become standard practice.

The success of the utilization programs can be measured, not only by research results, but also by the successful application of these results to industry. Adequate dissemination of information through such media as publications, symposia, and industry advisory committees should be well planned and maintained.

Basic Research

Results of the utilization research program continue to demonstrate the importance of fundamental or basic research. This area should continue to receive major emphasis.

Basic research is the foundation upon which applied research and product development must be based. The success of application is entirely dependent upon the breadth and depth of the fundamental information obtained. It is difficult to evaluate results of these research programs in terms of dollars or products, which are the effective means of obtaining financial support. Protection for the future National welfare demands constant emphasis on sound and adequate basic research programs.

Expansion of Laboratory Facilities

Utilization research presently encompasses a broad and comprehensive program. The present and currently funded regional laboratories, together with their satellite facilities and the program of contracts and grants, provide adequate geographical and physical distribution. The further addition of separate facilities, which do not appear to be necessary to execute present programs from a physical standpoint, would place an additional drain on competent administrative talent and would compete for scarce reserves of trained scientists. Economies will be effected by maximizing the use of all types of equipment and instruments, and efficiencies are to be gained in related fields by the commingling of scientists, any one of whom may stimulate the work of others. This Committee feels that the utilization research programs can be handled very adequately for the foreseeable future by expansion of facilities in laboratory locations supplemented by grants and contracts. Any future expansion in this area should be the subject of careful study before further laboratory locations are considered.

Training Programs

The Department is to be commended for the programs offering opportunities for the training of professional personnel. The rapid advances in technology and instrumentation necessitate constant effort in this direction if maximum efficiencies are to be realized. Aggressive implementation of these programs for selected personnel is in the best interests of the Department, as well as the individual scientist. Both funds and opportunities should be provided. Scientists with longer records of service should be encouraged to take advantage of opportunities for refresher courses as well as work toward advanced degrees.

Contracts and Grants

The importance of outside contracts and grants to assist the regional laboratories in carrying out the utilization research and development program is recognized.

Highly competent manpower and suitable equipment are available in State experiment stations, industry, and other laboratories, which can and should be utilized in the solution of specific problems, particularly those which may be nonrecurring. Much duplication of equipment and competition for manpower can be avoided by this means, in addition to the savings in costs that may be effected. In addition, any effort is to be encouraged that

stimulates activities carried out in conjunction with colleges and universities which prompts our talented youth to become interested in following a career directly or indirectly related to agriculture, and more particularly, to carrying out the type of research sponsored and conducted so effectively by the Utilization Research Laboratories. It is recommended that the contract and grant program be continued and expanded.

Environmental Pollution

One byproduct of most agricultural processing systems is usually some form of environmental pollution. The Committee recognizes the Department of Health, Education and Welfare as having major responsibility in this field, but hastens to recommend that the Department of Agriculture, through its utilization research program, maintain an active interest in the abatement or prevention of such pollution. The success of present and future processes for the utilization of agricultural products will soon be predicated on the extent to which they minimize or avoid contributions to environmental pollution. Prevention is the most effective control of pollution, both air and water. This should be an integral part of all process investigations.

Utilization of Contaminated Food and Feed Materials

As more sophisticated methods are developed for the detection of various contaminants, such as chemical pesticide residues, bacteria, mycotoxins, etc., increasing amounts of foods, feeds, and forages will be considered unacceptable for use by humans or animals. These materials might conceivably amount to millions of dollars in value. Certainly, efforts should be made to find means of utilizing these sources of food and fiber. More precise and more accurate analytical methods must be developed. Utilization research might attack this problem from the standpoint of (1) development of techniques for the removal of these contaminants, (2) inactivation, (3) destruction, or (4) other possible uses. The Committee recommends that utilization research programs include work specifically in these areas.

Preliminary Evaluation for Safety and Toxicity

Utilization research has resulted in a vast number of processes and products which are of tremendous value to both agriculture and the consuming public. Many of these developments utilize well-known chemicals in new reactions, and many new compounds are formed. Since everyone concerned with food or feed supplies is charged with the safety of those products, it is recommended that the regular program of evaluation of new products should include preliminary screening for safety or toxicity. This would require the provision of at least minimal small animal facilities at each of the laboratories for this purpose and would be in addition to the fine program being carried on at the Western Laboratory. Final clearance for use should be the responsibility of industry when the products are developed for commercial use, but, as a minimum, determination of acute toxicity of new products should be one of the responsibilities of utilization research. This has been done in many cases in the past, but it is recommended that this be a recognized part of the program.

Odor and Flavor

Odor and flavor in foods or odor in such products as apparel, home furnishings, etc., may be critical in determining the usefulness of products. While subjective methods are useful, development of completely objective measurements would be highly desirable. A significant effort to develop such techniques seems basic to the evaluation of certain types of products, and should be sought.

Developing New Food Products to Meet Specific Needs in Foreign Countries

The world food deficit centered in underdeveloped and developing nations is a continuing threat to international peace and economic security. Great opportunities exist to process and distribute new food products tailored to the needs and habits of specific populations in Africa, South America, and Asia, both in countries that are able to sustain commercial markets and in those that must depend upon donations and concessional sales while they strengthen their local economies. Research should be intensified on new food products that will permit this country to capture its share of the existing and potential food markets overseas. Additionally, information should be developed which will permit us to make intelligent recommendations for the use of indigenous food supplies, thus helping to reduce the need for food contributions from this country.

Nutrition

Because of the major utilization research effort directed toward the use of agricultural commodities for food and feed, a serious effort should be made to provide for adequate nutritional and physiological evaluation in animals or humans, as appropriate. In order to achieve effective progress in this area, it is imperative that such evaluation studies be closely coordinated with work on crop constituents of biological significance, particularly as they may be affected by processing. Further, serious consideration should be given to using part of the proposed small animal facilities at the regional laboratories for providing biological data of a screening nature which are needed as guidelines in the identification, isolation, and transformation of the physiologically active constituents.

Fibers and Leather

The relative use of cotton and wool fibers and hides continues to decline each year in the competition for markets in apparel, home furnishings, and industrial products. The research effort of the chemical industries, from which synthetic materials flow in ever increasing volume and variety, is known to be many times larger (in investment and personnel) than that currently available in support of fibers and hides from our farms and ranches. The research effort of our industries properly is given credit for the expansion in the use of synthetic fibers and for the threat to the market for leather. It should be recognized, therefore, that the preservation of a reasonable share of former markets for natural fibers and hides requires research effort

aimed at a reversal of the present trend. We recognize and appreciate the success achieved by the existing level of utilization research on fibers and leather in the regional laboratories and the areas of new uses and improved products of cotton, wool, and leather this effort has generated. However, we recommend that the utilization research budget be increased or reoriented to permit a significant increase in utilization research and process development in these agricultural commodities.

CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES

Foods

Knowledge of the components of animal and crop products should be expanded to provide a solid basis for developing new and improved processed products. Also, research should be expanded in the development of fundamental information on the compositional changes which occur during processing. More rapid and sophisticated analytical methods must be developed to obtain needed information on the basic composition of food ingredients and food products.

Investigations into the cellular and subcellular composition and structure of grains and oilseeds is a highly significant and productive area of research and should be continued and expanded. Similar research should be expanded with fruits and vegetables. With the development of more convenience foods, a better understanding of the subcell composition and ultrastructure; the morphology of the cell; the interrelationship of its components; the function of water or moisture in the cell composition; and changes which occur during maturation, the post harvest period, and storage as well as during processing and rehydrating will lead to a more effective utilization of the products.

Research efforts in the fractionation and characterization of proteins from oilseeds, wheat, and other grains is to be commended and should be intensified with a view not only to the development of compositional knowledge but also to a better projection of their potential utilization. Similar studies on the lipid and carbohydrate fractions of grains and oilseeds would supply useful information to fill the basic knowledge gaps now existing, and would help in a better understanding of their utility. In addition to the investigation of protein-protein interactions, it is recommended these investigations be expanded to include protein-lipid and protein-carbohydrate interactions during processing and food preparation.

Utilization research on sugar was terminated in fiscal 1966. This is an important and significant domestic farm crop. Much still needs to be known about the composition and effect of nonsucrose components on processing procedures and about correlations of composition with processing quality to provide guidelines for new processes and varieties aimed at improving the economics of sugar recovery. Research studies should include investigations into possible new and useful byproducts, including products for uses other than foods. The Committee highly recommends reinstitution of compositional studies in the area of sugar producing crops.

The current research programs relating to the structure and characterization of milk proteins and the studies of the genetic casein variants have been highly productive and should be pursued vigorously in the coming year. This work holds much promise for elucidating the processing characteristics of milk proteins as well as for the isolation of allergenic substances in milk.

The study of chemical and physical properties of meat and eggs should be expanded with the hope of identifying factors responsible for giving raw materials desirable characteristics in their utilization, including further processing. This will make meat and eggs more useful in the preparation of consumer convenience items. Information is needed on the contributions of the several types of tissue present in poultry and other meats.

Methods of handling livestock and methods of handling meat affect chemical composition and physical properties of edible tissues. Studies are suggested to develop information on the influence of various processing methods on protein quality, flavor, tenderness, moisture retention, and other characteristics that influence consumer acceptance. A study of the chemical and physical properties of meat proteins and other constituents and processing procedures influencing meat emulsions should prove most useful.

A far more complete determination is needed of the natural protein and amino acid content of meat. This includes differences that may exist in different cuts of meat within the same animal and from animal to animal within the same species. Also, similar information is needed for the several species of meat animals including poultry.

More information is needed on the minor constituents of fats and oils. There are many constituents, nonglyceride in nature, in both animal and vegetable fats. Modern methods for separation and identification of materials today should reveal much more than is now known about these minor constituents. Their effect on stability, color, and odor should be studied. Once the character of these constituents is established, ways for controlling them can be developed.

The effect of the characteristics of edible fats on human nutrition and health is under intensive investigation. Research designed to modify fat during the antemorten and/or post mortem periods to obtain the desired nutritional and functional characteristics is to be encouraged.

Feeds

With the advent of computer formulation of mixed feeding rations for farm animals and poultry, there is an urgent need for accurate and systematic data on the composition of feed grains, oilseed meals, forages, roughages, and animal products for feed. Such data must include the basic constituents, such as protein, fat, fiber, essential amino acids, vitamins and minerals. In addition, there is need for reliable energy values. It is important that these data provide information on both average values and range of values on commercial products. Their acquisition will require the evaluation and development of reliable analytical methods and sampling procedures.

In order to improve the value of agricultural crops for feed, it is recommended that fundamental investigations on the physical, chemical and biological properties of major and minor constituents and interaction of these constituents with other nutrients be emphasized. It is necessary that these studies on properties be related to nutritional value for farm animals and poultry. Changes in the nutritional value of components as a result of storage of both agricultural crops and feed ingredients processed therefrom should not be overlooked. Further, an understanding of changes in these components during processing can provide valuable clues to improved processing methods.

Among the physiologically active feed components which require further basic investigation are the growth inhibitor(s) and essential trace metal-binders in soybeans, gossypol and cyclopropenoid fatty acids in cottonseed, and coumestrol and carotenoids of alfalfa.

There is continuing need for rapid methods to assess the nutritional availability of limiting amino acids in processed protein products for feed. Although much progress has been made in determining the availability of lysine, this deserves further attention. It is equally important that studies be undertaken to develop rapid methods for evaluating the nutritional availability of other amino acids such as methionine and threonine. Such work must include a study of the range of utility of these methods as applied to a diversity of protein products used for feed.

Fibers and Leather

The only, and the essential, source for the initiation of new and improved products and processes utilizing cotton and wool fibers and leather in consumer and industrial products is improvement in our knowledge of their structure and their chemical and physical properties. Our capacity to define these structures accurately will permit their designed modification and improvement and lead to their use in new and improved products.

The improved cotton, wool, and leather products which are now in commercial distribution are adequate evidence of the utilization of such new knowledge and improved technology. This utilization research effort must be increased and not be deferred until the urgency becomes even more serious.

It is suggested that the added utilization research effort in chemical composition, structure, and physical properties have priority in part applied to each of the following categories and areas of prospective product and process enhancement in cotton and wool fibers and leather utilization:

> Investigations of the structure and properties of cotton should lead to processes and finishes which enhance its resistance to weather and microbial damage. Efforts in this area should be maintained.
>
> Basic investigation of the chemical and physical breakdown of the proteins of wool and mohair occurring as a result of exposure to

heat, light, moisture and chemicals should be continued. More knowledge should be obtained about the nature and location of reactive sites in the different parts of the wool and mohair fibers and their molecules.

Increased knowledge of the structure of leather is a major requirement before new modifications and improvement of its properties in footwear and fabrics can be fully achieved. Microscopic and chemical investigations should be extended.

Industrial Products

(Cereals)

Corn is our largest volume agricultural crop and is generally available at about 2¢ per pound. Its current and potential industrial uses are great. Other cereal grains are also in abundant supply and available at reasonable costs. Development of new uses and expansion of present industrial outlets for products from corn and other cereal grains will be influenced by the extent of knowledge of their chemical composition and physical properties. Continued work to elucidate their chemical composition is essential.

It is suggested that supplemental work be considered on the effects of today's trends in agronomic practices and genetic developments on the physical and chemical properties of corn and other cereal grains. This might include such factors as the effects of ferilization on composition and of methods of harvesting and drying on physical structure.

(Oilseeds)

Although considerable is known about the composition and structure of soybeans and work is continuing to gain such information, it should be stressed that much still remains to be done if soybean products are to achieve their maximum industrial utilization. Continued compositional studies on the whole bean and especially the protein components should be effectively pursued as an aid in the preparation of new and improved industrial soy protein products. The chemical and physical characteristics of soy proteins isolated by different means should be determined as an aid to their industrial utilization. Similar information is needed on cottonseed, peanut and other oilseed proteins.

Chemical composition of linseed and other drying oils has been generally known for many years and their good properties utilized in durable paints, inks, linoleum, concrete penetrants, etc. Much less well known are the successive chemical steps whereby a dry film formed from linseed and other oils gradually degrades from a pale, water-repellent, tough, elastic film to a water-sensitive, irregular, weak surface which is ultimately neither protective nor easily repaintable. Moisture, actinic light and fungal attack from within or without are common causes of this degradation. Elucidation of chemical reactions and successive products of these degradations could aid in finding means of prolonging the life of linseed oil paints. New, available, sophisticated

instrumentation enables more precise identification of both volatile products and residual solid fragments from degradation.

Chalking of paint, as a function of pigment wetting and pigment-vehicle chemical interaction, is even less understood, yet relates directly to tint retention and overall appearance as well as durability. Here, again, basic studies of detailed mechanisms are strongly recommended.

Studies of safflower which interrelate fatty acid content with amounts of hull, meal, and undesirable odor or other components are commendable and should be continued. Both edible and industrial uses should be sought, particularly a low cost oil with unique fatty acid compositions. The paint and allied industries have need for vehicles superior in paleness and odor to those derived from linseed and soy oils. The technologies for use of such oils are already well advanced and await a favorable balance of supply and cost.

The chemical composition of castor oil is well known and its opportunities for reactivity toward manufacture of useful products are promising. However, it is necessary to continue studies of castor meal, hull and castor allergen to reveal more details of their composition and reactivity in order to make economic the utilization of the whole castor bean. The Department is to be commended on its progress in this area and encouraged to continue its investigations.

Studies of composition of major and minor constituents of new oils, proteins, carbohydrates or other product classes in candidate new crops deserve relatively constant support, year by year, as insurance against scarcity of various commodities due to adverse weather or unreliable foreign supply. Forecasting of needs in terms of composition should be a primary guide. For example, a domestic source of a lauric acid type oil would stabilize and enhance supplies for manufacture of biodegradable detergents, functional fluids, plasticizers, color retentive, nonoxidizing alkyds and other polymers for paints. Cuphea llavea oil, with capric acid as a major constituent might develop into a partial answer to this need.

Dimorphotheca and lesquerella oils and their seeds deserve further studies for comparison with castor oil, in view of its allergen problems, as preferred sources of hydroxy fatty acids. Vernonia seed deserves further study for reason of the epoxy content of its oil but should be repeatedly reviewed and checked for its economy versus epoxy oils derived from readily available oils.

(Tobacco)

Tobacco, with an annual value of six or more billion dollars in taxes, farm income, processing and marketing, has recently been adversely associated with certain health problems. The utilization research and development problems incident to a favorable resolution of this matter are of such magnitude and of such immediate economic importance that expanded and carefully considered research must be directed to essentially all immediate and long range investigations which hold significant promise.

Within the past two decades knowledge of the chemical composition of tobacco and tobacco smoke has grown to the point that it is likely no other plant material and its complex end use products are known in such detail. In spite of the extensive prior and present effort, major areas of identification and investigation remain. Areas of primary importance which deserve continued and increased effort include: (1) elucidation of the physico-chemical mechanisms of smoke formation and formation of smoke components with the view of effecting useful modifications based on a scientific understanding of the processes and thus of the factors of importance in the processes; (2) carefully conceived studies to establish the association of precursors in the tobacco with the smoke components produced in the smoking process and (3) quantitative chemical analysis of some significant fractions which as yet have not been adequately resolved, e.g., the "phenolic" fraction, the substituted polycyclics, etc.

In all investigations, the significance of the results will be greatly increased if experimental conditions closely approximate conditions prevailing in the normal smoking process, e.g., products of pyrolysis at 850°C may bear little qualitative or quantitative relation to those obtained in the normal smoking process if the sample material decomposes thermally, at say 350°C.

In the area of longer range studies there is need to (1) improve and devise analytical methods applicable to tobacco and smoke constituents, (2) quantitatively identify in the several types of tobacco the major chemical entities associated with aroma and flavor and to understand factors which enhance desirable aroma and flavor, (3) determine the specific change in chemical constituents which occur in the ageing in air storage and in the fermentation process and the relation of these changes to the smoke components produced by such tobaccos and (4) determine for the several major types of tobacco the components which contribute most importantly to the quality of good tobacco.

Because of the experience and the information developed in industry laboratories in the field of tobacco and smoke chemistry and physics, it will be highly beneficial to both the USDA and the industry if close liaison is maintained between the utilization and the industry laboratories.

(Naval Stores)

Chemical composition of the several classes of compounds in naval stores is rather well characterized and needs only to be updated in terms of new, more sophisticated analytical methods. However, the characterization of successive degradation products of rosin acids, whether in the resin streak of a piece of house siding or in formulated paint films, would reveal in useful detail the more vulnerable sites of these complex molecules. Vulnerability implies reactivity, which might be turned to useful synthesis via the same factors of atmospheric oxygen, moisture and actinic radiation.

Between the two major components, terpenes and rosin acids, in naval stores the first enjoys more long range and wide economic use. For instance, the

old, wasteful dissipation of turpentine merely as a volatile (lost) solvent for paint is largely supplanted by more sophisticated and valuable products synthesized profitably by industry. A similar upgrading of the uses of rosin acids is implied.

Paint exposures over the past decade have emphasized semi-quantitatively the close interrelation of light, oxygen, and moisture in the degradation of paint films. Still more sophisticated study of these interrelations on simpler compounds, e.g., abietic acid, could lead to new, economic syntheses competitive with crude air blowing and more refined ozonolysis and peroxidation.

It is recommended that basic studies be undertaken on the chemical mechanism of degradation by atmospheric oxygen, moisture and actinic radiation on one or a few of the commoner acids in rosin, e.g., levopimaric and abietic acids. This knowledge may then be useful in exploratory synthesis.

FLAVOR

The Committee is pleased to note that greater emphasis is being placed on flavor and consumer acceptability in all of the food research efforts. Some of the areas of research that should be expanded are:

> Investigation of the causes of loss of desirable, and the development of undesirable, flavors in dehydrated fruits, vegetables, and other processed plant products.
>
> Studies of bread flavor stability and of the development of other desirable flavors derived from processing and cooking.
>
> Basic and applied studies on the characterization of undesirable flavors and their precursors for developing food protein ingredients having acceptability in a wide variety of food items, both domestic and foreign.

Basic investigations should be initiated on the mechanisms of the biosynthesis of flavors in fruits and vegetables. The role of enzyme systems in the development of flavor constituents from precursors should be a fundamental aspect of this basic study. By understanding the mechanisms involved, better control of desirable flavor development and stability can be attained. With improved techniques and methodology, investigations should be continued in isolating and identifying new flavor components in animal and plant products.

A comprehensive study of flavor changes in nonfat dry milk during manufacturing and storage should be undertaken. The nature and control of the stale flavor deserves special attention since substantial quantities of this product are involved in a host of domestic food applications, as well as in our foreign aid programs.

The dry milk research programs of the Department should include additional packaging studies and investigation of antioxidants and other flavor-stabilizing additives. Conventional dry whole milk must now be packaged in

hermetically sealed metal containers (plus vacuum and/or nitrogen treatment) which adds much to the cost of the product and thereby limits its use. Cheaper packaging and flavor stabilizing additives or procedures should enhance the market possibilities of this product.

The demand for convenience foods has prompted the development of many new meat and poultry products. This activity creates new problems, particularly when the convenience foods are precooked and need only to be heated to the desired serving temperature prior to being consumed. Additional investigations are urgently needed to determine the factors responsible for "warmed-over" flavors which characterize so many precooked convenience foods. Also, meat and poultry tend to lose their characteristic flavor when tissues are disassociated prior to incorporation into convenience foods. A search for additives that stabilize or enhance the desirable flavor characteristics of foods is encouraged.

Flavor change in hydrogenated soybean oil is not a serious problem from a commercial standpoint today. In contrast, the use of soybean oil as a cooking and salad oil and its use in margarine is definitely limited because of flavor instability. It is realized that much has been done on this problem, yet it is not solved. The domestic and export use of soybean oil is tremendous, but it would be even greater and the quality of products made from it much improved if flavor stability could be improved.

The Committee recommends that more effort be given to selective hydrogenation of soybean oil as contrasted to partial hydrogenation and winterization. It is important that rapid progress be made in order to establish whether this approach affords a practical solution to the long recognized and much researched instability problem. Since the instability problem may be further related to certain minor constituents of the oil,these factors deserve investigation. In addition, flavors associated with typical oxidative rancidity, which occurs in other vegetable oils and animal fats, deserve continued investigation as part of an effort to provide foods and food ingredients having greater shelf life and improved consumer acceptability.

Information is needed on the influence of processing methods, including irradiation, dehydration, canning and other methods of preservation, on flavor. The influence of salt in cured and uncured products on flavor, including the development of rancidity, should be further investigated.

While much is being added to our store of knowledge as far as flavor components are concerned, we need a more complete understanding of the intensification of meat flavor in older birds and older animals. Attention should also be given to the "unusual" or unnatural flavors that develop in meat and egg products.

COLOR, TEXTURE, AND OTHER QUALITY FACTORS

Studies of the natural pigments, their precursors, and transformation in animal and plant products should be expanded with emphasis on the development

of processing technology that will preserve, protect, and provide optimum color values in foods. Improved techniques or systems for evaluating meat characteristics should be developed to provide information useful in the producing, processing, and marketing of meat. It is further hoped that the results of these studies will permit a more objective recognition of characteristics desired by consumers.

Fundamental studies with respect to enzyme activity and other factors as they apply to plant and animal products in the areas of color, flavor, texture, tenderness, and moistness are needed.

The physical structures responsible for texture in both plant and animal products should be established so that optimum quality can be furnished the consumer. In this area, improved methodology and the development of basic concepts of the structural units responsible for texture that meet consumer preferences are needed.

Study of factors influencing the textural qualities of frozen and dehydrated fruits, vegetables, and meats should be expanded. A better understanding is needed of the factors which contribute to turgor of fresh fruits and vegetables. Studies of means of retaining turgidity in (1) frozen products after thawing and (2) dehydrated products after rehydration should also be expanded.

Recent research has shown that exposure of dairy, oilseed, and cereal products to heat and moisture during processing can bind substantial proportions of the lysine present so that it is nutritionally unavailable, and methods have been developed for the determination of available lysine. There are indications that other amino acids, notably threonine and methionine, may also be bound. Research should be initiated to develop methods for evaluating available bound threonine and methionine and to explore the influence of processing conditions on the availability of these and other essential amino acids. With the growing interest in a knowledge of the true nutritional quality of food products and food prototypes, it is suggested that serious consideration be given to the establishment of appropriate and adequate nutrition evaluation facilities at each Regional Laboratory to provide the necessary guidance for both fundamental and applied studies.

Work in progress on the evaluation of oilseeds and legumes and products derived therefrom as the source of digestive disturbances, particularly flatulence, is important to their full utilization in foods for infants and adults and in pet foods. It is recommended that additional effort be made to identify the responsible agent(s), and to devise methods for eliminating or inactivating them by practical processing methods.

The extensive losses experienced in dressed poultry due to breast blisters and bruises calls for increased research seeking to improve methods of handling birds and to develop equipment and methods of operating it in order to reduce these wasteful losses. Further basic research is required to determine the possible relation of nutrition, genetics, disease exposure, and environmental control to the predisposition of chickens and turkeys to developing grade-lowering blemishes.

The results of some investigations indicate that poultry should be "aged" before freeezing for maximum tenderization. More research is needed to guide processors in methods of handling dressed poultry consistent with quality, including texture and tenderness.

Loss and downgrading of eggs because of shell defects remains high. This is particularly true of eggs produced toward the end of the laying year. Major losses also result from bone breakage when processing, for example, cage layers. It appears that shell quality and bone fragility in cage layers may be related. Studies should be expanded on the physiology of shell formation and the effect of mineral composition of the diet, genetics and the effect of management on shell quality and mineral metabolism of the bird.

Research relative to pigmentation and/or discoloration in meat should be expanded. During recent months there has been an increase in the number of reports calling attention to a condition in which chicken or turkey meat heated to a well-done state sufficient for normal cookery appears to be uncooked. Information as to the chemical nature of the pigments responsible for this condition is incomplete. Factors responsible for differences in the color of raw muscle tissue in pork are not completely understood and should be further investigated.

Improved techniques or systems for evaluating meat characteristics should be developed to provide information useful in the production, processing, and marketing of meat. It is further hoped that the results of these studies will permit a more objective recognition of characteristics desired by consumers.

MICROBIOLOGY, TOXICOLCGY, AND FERMENTATION

Foods

Investigations should be expanded on the use of microorganisms to develop fermented products from soybean, wheat, and other grains resulting in special attributes such as desirable flavors and textures, improved nutritional qualities and optimum processing characteristics.

The question of the heat resistance of spores in sterilized milks and other heat processed foods will have an important bearing on future developmental efforts, and work on this problem by the Department should be substantially expanded. If means can be found to destroy spores at lower critical temperatures, substantial improvement in shelf life and in flavors and physical properties should be realized.

In view of mycotoxin production by certain species of mold, it is suggested that a careful study be undertaken to determine the presence or absence of these substances in mold ripened cheeses. It is most important that practical methods be developed for the inactivation, destruction, or removal of the toxic substances when present in agricultural products.

Losses of agricultural products from microbial deterioration prior to and during processing and in the channels of trade are considerable. Research should be expanded to make it easier to obtain effective sanitation in the processing and handling of foods and thus reduce the number of food spoilage microorganisms as well as bacteria having health significance. This involves a determination of suitable cleaning agents and techniques and may involve the development of new equipment.

Pasteurization is our best tool for controlling salmonellae in liquid eggs. However, no present method appears to be completely effective and continued research is recommended.

The possibility of heat resistant strains of microorganisms evolving in a pasteurizing program should be thoroughly investigated.

Research should be expanded to develop improved methods for sampling and testing products. Particular emphasis should be placed on simple, rapid, reliable, and economical methods for the detection of salmonellae and other microorganisms. Emphasis should also be placed on the development of nonmicrobial techniques for evaluating the effectiveness of particular sanitation procedures.

The collection of analytical data in testing a new analytical technique through collaborative effort is encouraged so that effective recommendations for acceptable methodology may be made.

Feeds

Mycotoxins arising from the growth of field and storage fungi pose a serious threat to the full utilization of feed crops, processed feed crops, and crop residues used for feed. An intensified research effort is needed to define molds and mold strains producing toxic metabolites, to provide methods for the detection of these mold metabolites, to assess the toxicological responses of the metabolites, to define environmental conditions necessary for production of the mycotoxins and then to devise means for the removal or inactivation of the toxic substances. Because of the health hazards to both animals and humans this work must be intensified.

More information is needed on constituents of feed crops and processed feed crops that produce toxic responses in farm animals or poultry. This work should be stressed as part of the effort to develop improved feed ingredients.

Industrial Products

The production of chemicals or other products from cereal starches or derived carbohydrates is economically attractive and considerable progress has already been made. A continued and expanded screening of the Department culture collection for potentially useful applications of fermentation systems to cereal grains, starch and glucose is in order. Work on fermentation techniques is commendable and we recommend further development of continuous fermentation processes. Expanded work on the development of basic information on enzyme

systems is recommended.

Biodeterioration of linseed oil based paints and other exterior paints remains one of the most difficult aspects of paint technology, particularly for paint service in the Southern United States. Lack of practical fungicides which are effective for most of the long life of an exterior paint is an important threat to the continued use of linseed or other glyceride oils in paints. Elucidation of the detailed chemical reactions in the role of linseed and other oils in the metabolism of fungi should aid in the design of better fungicides to long delay or prevent the biodeterioration of paints by fungi reaching the paint from its substrate or from the atmosphere.

This need for more information about the relationships between paint oils and fungi implies a coupling with other needs across much of agricultural science to learn generally and in detail the chemical and physical mechanisms which occur in the several structural parts of destructive microorganisms through their life cycles, to control better the host of hostile fungi in our environment.

Enzymes

Nature has provided a vast array of agricultural products for man's use. In the plant, animal, or microbial organisms which produce these products, the composition and physical characteristics are determined by catalysts which control all life processes. These catalysts are complex organic molecules that can be recovered from natural biological systems, identified and in turn used to promote specific organic chemical reactions. Since enzymes, as these catalysts are called, are specific and capable of directing complex chemical breakdown or synthesis of products, they have potentials far beyond our present simple utilization of them.

The Department now uses enzyme reactions in many developments such as in hydrolysis of starch to glucose and in preparation of polysaccharide from glucose. In fact, this is an example of enzymatic breakdown or hydrolysis of a large carbohydrate molecule (starch) of one type to simple glucose units with one enzyme system. Then another enzyme system is used to synthesize from the glucose a large carbohydrate molecule of a different type. Other systems exist for protein alteration, antibiotic production, chemical manufacture, etc.,--all using agricultural products as raw materials.

The Department has the world's greatest collection of microbiological cultures. These are the sources of many types of enzyme systems about which our knowledge is comparatively meager. We commend the work in this field and would like to suggest additional work in this area.

It is recommended that serious consideration be given to severalfold expansion of fundamental studies on microbial enzyme systems. Such work requires a high level of scientific effort but the potential value is unlimited. The resource material is available. The work is not being done elsewhere in the world. The USDA has the scientific and financial support. The objectives could be to:

Develop fundamental, scientific knowledge of all types of enzyme systems.

Learn to control these in the curing and processing of natural food, feed, and fiber products.

Isolate and produce enzymes or enzyme systems for specific reactions.

Develop new and useful food, feed, and industrial products using these enzymes.

This is indeed a long-range project, but many useful products or processes would be derived early. Their number and importance would be expected to multiply rapidly as scientific advancements build one upon the other in this field. Results of the work would apply to all commodities and crops. In its early development, this research could be done most effectively and efficiently by assembly of the world's best talent in this field at one location and providing them with the proper scientific equipment to do the job.

EXPLORATORY CHEMICAL AND PHYSICAL INVESTIGATIONS

Fibers and Leather

All new approaches to cotton modification and resultant improvement in use and service properties are to be encouraged at this stage of our utilization research without thought of ultimate cost. Of course, careful screening for potentially commercial concepts gives priority to the technology needed for product and process changes.

Improvement in the resilience of cotton fibers and fabrics is of major interest in its competition with synthetic fibers. All approaches to such improvement must be explored. These include methods of crosslinking and polymerization, added chemical components, and radical yarn and fabric modifications in structure and morphology by combined chemical and mechanical processing. Such explorations require pilot plant effort of considerable cost which should be fully supported in the research budget.

Basic studies should be expanded on effects of chemical reagents and the physical conditions which produce changes in the setting and wrinkle recovery of wool garments.

Research should be initiated on providing permanent protection to wool products from insect and microbial attack with non- or low-toxicity compounds, using interfacial polymerization or chemical grafting techniques.

Pilot plant studies on electrical discharge and ozone treatments should be vigorously pursued to establish optimum conditions necessary to produce wool yarns with durable stretch and high bulk and softness.

Exploratory research should be extended in the area of the use of polyfunctional reagents leading to leather with resistance to shrinkage, microbial damage, perspiration, and chemicals. Appearance retention and added resistance to abrasion also are desired goals of this effort.

Investigations into the use of cuttings or edges of hides in other fields such as edible uses or particularization and reconstruction in sheet form for the creation of leather products with new features and uses is a desirable goal of exploratory work in leather utilization.

A review should be made of the attributes of synthetic products which are replacing leather in consumer and industrial use. This will aid in the search for methods of improving properties of leather by new processing techniques and the addition of preformed polymers which give new and desired attributes in leather products.

Industrial Products

(Cereals)

The new papermaking equipment at the Northern Laboratory facilitates evaluation of cereal products in paper manufacture. Since this is one of the major industrial uses of starch, this tool should be of great help in the development of information on the role of various cereal starches and derivatives as paper sizes, paper adhesives, paper coating binders, etc. It is recommended that projects in this area be aimed at supplying information which will be useful to the development of new products or more effective use of present starch products in papermaking. Work on the new high amylose starch is encouraged. The extent of effort should be kept commensurate with the potential use.

(Oilseeds)

Most soybean products are used in foods and feeds but soybean oil is used extensively in industrial products such as in coating resins and as epoxidized oil in vinyl plasticizers. Basic researches on fatty acid and glyceride reactions are to be encouraged. In view of needs for effort in other areas, it is suggested that the work of aldehyde oils be objectively reviewed to assure that the effort is commensurate with the prospective potential. Since low cost dibasic acids would have considerable use, it is suggested that a project be initiated to study preparation of dibasic acids from soybean oil by catalytic air oxidation and other potentially practical means.

N,N-substituted amides, derived from cottonseed oil acids, should be further explored to complete feasibility studies for use as plasticizers in various high polymer systems. In general, exploratory research on amides and other chemicals derivable from cottonseed and other oils should be encouraged so as to develop fundamental information on the chemical and physical properties of a wide array of derivatives, some of which will undoubtedly contribute to new or expanded industrial use of the oil commodity.

Exploratory investigations to broaden the uses of linseed oil should be continued and reoriented periodically as industry accepts and uses the resulting technology. Successful use of linseed oil for preservation of concrete pavements and related structures should be restudied for interpretation toward strengthening chalky stucco and other masonry surfaces for which paints based on nonsaponifiable vehicles such as chlorinated rubber have tended to displace those based on linseed oil. Measurements of rates and products of saponification of the oil and of its penetration and waterproofing qualities are needed to maintain its competitive position.

Exploratory studies of various reactions of linseed oil and its fatty acids are commendable. It is suggested that rather than elaborate upon the yields of products related to the commercial practice of ozonolysis of oils, alternative processes be sought toward the same type of end products. For example, reaction intermediates and products from close control of interrelated atmospheric oxygen and moisture, light or other selected bands of radiation, time and temperature could lead to equally useful products as well as elucidate the details of degradation of a dried film in various natural environments. This is complementary to the need for understanding and suppressing the yellowing of linseed oil to regain its use in paints lost to more color retentive vehicles.

Exploratory chemical and physical investigations of castor oil have shown promising results and should be continued in the direction of varieties of chemical reactions and estimation of yields and costs. An array of monomeric hydroxy, keto and other monomeric products from castor oil will challenge the ingenuity of chemical industry, and should not be limited to narrow attention to any single candidate product. It is doubtful if castor derived hydroxyl prepolymers for urethanes can compete economically with related prepolymers of petroleum origin in either foams or coatings and this project should be reviewed.

It is also questionable that a castor-derived or any other acrylate ester from an alcohol having more than 8 or 10 carbons can find a secure place in major acrylate copolymers of commercial importance. Novel reactions for producing various difunctional monomers, e.g., omega hydroxy acids or dicarboxylic acids are commendable. Novel polymers from raw castor oil should be sought.

Exploratory chemical and physical investigations of uncultivated plants as sources of potentially valuable crops should have a steady, though limited, year to year support to disclose new opportunities in agricultural resources.

(Naval Stores)

Exploratory chemical and physical studies of both terpenes and rosin acids should be continued on a wide basis. Current successes in useful products synthesized from each are indicative of more to be sought. The considerable work on Diels-Alder adducts of rosin acids may have been carried to a sufficient degree for deemphasis in favor of other exploratory work.

Synthetic efforts should be focused on the more vulnerable or reactive unsaturated ring of the rosin acids molecules to transform this instability into useful functionality and product stability. Doubly difunctional monomers should be sought from rosin acids as precursors of ladder polymers for improved heat stability needed in space vehicles, aircraft, electrical insulation, etc. Current successes from polyamides, polyimides, polyesters, and heterocyclic polymers are only partly adequate and work continues. The complexity of the rosin acids molecules offers much opportunity for ingenuity in chemical synthesis of these polyfunctional monomers. It has been predicted that a successful ladder polymer will contain little hydrogen. This suggests the fused rings of rosin acids molecules as starting materials.

(Animal Fats)

Economically favorable markets for the supply of inedible fats and oils have been declining and higher priced outlets need to be developed to effect an improvement in this situation. After appropriate chemical modification, the most promising outlets appear to be in the fields of detergents, plasticizers, lubricants, chemical intermediates, and monomers for polymer and copolymer production.

Studies of chemical composition and degradation characteristics should be continued with the various inedible fats to the point that both major and minor components are well characterized as to chemical reactivity and structure. Based on a careful assessment of the most promising industrial products or other potential uses, efforts should be directed to the production of competitive or new raw chemicals and/or finished products for appropriate utilization tests.

PROCESSING INVESTIGATIONS

There exists a continuing opportunity to improve the value of feed crops, crop residues, and crop byproducts for feed through the development of new and/or improved processing methods. This is a potentially profitable area which requires continued investigation.

The oilseed crops deserve further attention in developing new methods of oil removal and processing of oilseed meals to increase nutritional value. Particular attention should be devoted to new methods which preserve the nutrient or beneficial components and remove or inactivate deleterious substances. Much good work has been done on developing a new solvent extraction method for cottonseed. This should be appraised for practical value in providing meal of improved acceptability and quality with view toward developing alternative approaches. The development of crambe and safflower as a source of feed protein should be completed so as to provide information which will permit an evaluation of their economic importance.

It is recommended that more effort be given to the processing of cereal grains and forage crops for increasing their feed values. This work should include the cooking of cereal grains, the fractionation of forages to provide high and low fiber products, improvement in fiber digestibility and the stabilization of valuable components of forage products among others.

and low fiber products, improvement in fiber digestibility and the stabilization of valuable components of forage products among others.

The development of pearl millet and Bermuda grass is important and deserves continued study.

TECHNOLOGY - PRODUCT AND PROCESS DEVELOPMENT

Foods

Food and food ingredient processing methods must be continuously evaluated in order to reduce processing costs and improve product quality, including the preservation and enhancement of nutritional qualities. Both basic and applied research should be expanded and directed towards:

Reducing the severe conditions of heat sterilization required to inactivate spores of food spoilage organisms

Reducing adverse color and texture changes that occur during freezing and dehydration, for example, in strawberries and green beans

Controlling processes to produce uniform high-quality products from variable raw material

Developing processes to utilize fruit and vegetables of good food value but unfit for fresh markets because of shape, size, or other condition

Developing new drying and concentrating techniques such as explosion-puffing and drying, concentration by osmosis or reverse osmosis, and adapting dehydrofreezing and foam-mat drying methods to a wide range of fruits and vegetables

Improving quality and reducing the cost of freeze-dried products

Developing instruments and techniques for objective measurement and control of product quality

Because an increasing proportion of fruits and vegetables are being marketed in processed form, new varieties must be evaluated as to their suitability for processing as well as for their fresh market characteristics. The introduction of mechanical harvesting methods also may affect the processing quality of the fruit or vegetable.

In cooperation with plant breeders, agricultural engineers, agronomists, and other scientists who develop new varieties, harvesting equipment, and cultural practices, utilization research scientists should evaluate the processing characteristics of food crops resulting from such experimentation. At this time, particular attention should be paid to the crash development of

mechanical harvesting equipment and its effects on processing quality of the harvested crop. In addition, attention should be given to the design and development of equipment and/or processes to permit the rapid and effective processing of foods, feeds, and industrial products from basic agricultural commodities.

The use of oxidative improvers to artificially mature hard winter wheat flour for best bread-making performance is not accepted in some European countries. This situation limits the role of United States wheat in the European community. Research needs to be expedited to develop acceptable new maturing treatments for flours and thereby improve the competitive position of United States wheat for export.

Valuable information about rice is being developed and should be continued in (1) "deep milling" investigations, (2) studies on chemical composition and physical properties as related to processing, (3) research on factors which influence the development of favorable flavor and textural characteristics during cooking, parboiling or instantizing, and (4) cooperative programs with State stations and others in the evaluation of new selections and varieties as related to milling and consumer acceptance qualities.

Protein products derived from oilseed crops and other agricultural crops are of growing significance in the development and manufacture of food products for domestic consumption, and provide an important protein resource for food in the protein deficit areas of the world. It is strongly recommended that new processing methods be developed to provide these protein products with improved food quality at reduced cost. Serious effort must be devoted to processing methods which improve the acceptability of these products as food ingredients and enhance their nutritional value.

Work on milk fat, cheese and nonfat milk has proceeded well and warrants continuation and expansion in certain areas. There is good evidence that stable butter oil or fractions thereof have several, yet undeveloped, applications in the baking and confectionery fields. For example, the inclusion of certain milk fat fractions has been shown to retard "bloom" in chocolate coatings, a serious problem in the chocolate industry. Likewise, the flavor-enhancing qualities of milk fat in bakery products is yet untested and warrants study. There is a lack of published information on the application of milk fat in the confectionery and baking fields, which suggests that these should be fruitful fields for utilization investigations.

With an anticipated increase of 250% in citrus fruit production during the next 10 years and per capita consumption of fresh fruit going down, considerable effort in fruit preservation is suggested. Dehydrated citrus products appear to have merit but serious problems in shelf life are indicated. In view of the obvious need for new forms of processed citrus fruit products to meet future domestic and foreign market needs and to utilize predicted harvests, it is recommended that intensive basic studies be undertaken now. Basic studies on citrus enzyme systems, flavor characterization and stability,

composition and relationship between components and quality factors deserve immediate attention.

There is interest in providing consumers with new and improved convenience foods using combinations of meats, plant proteins, and other ingredients to achieve maximum acceptance and stability. Research is needed to develop suitable processing procedures, ingredient selection, and packaging methods to assure optimum product quality.

As applied to poultry, it is urged that investigations designed to improve loading, transporting, dispatching, defeathering, eviscerating, chilling, boning, cooking, packaging, and storing be continued and expanded. An effort should be made to determine the effects of age, sex, diet, fat content, type of meat, and methods of cooking on heat transfer rates of poultry meat and on general quality.

In view of recent requirements for pasteurization of egg products by the USDA and a number of States, it is recommended that an information handbook or brochure be prepared. It should include information on the possible effects of pasteurization treatments on the properties of eggs and on destruction of microorganisms. The operation of equipment and effective sanitation methods should be emphasized.

Egg consumption has continued to decline for several years. One of the factors responsible for this decline may be the manner in which eggs are presented to the consumer in the market place. Studies should be conducted to find new and more effective methods of packaging and displaying shell eggs as a means of increasing egg consumption.

Investigations are encouraged that would develop a technology necessary to permit the production and handling of hard cooked eggs without shells on a commercial scale. This involves development of methods for removal of shells, packaging the eggs, and developing methods of keeping the cooked eggs for a suitable length of time.

The influence of pasteurization and other processing methods on the composition and functional performance of eggs in the preparation of food products including cooked items should be determined. A determination of the full nutritional impact of the egg in the human diet would be desirable.

It is recommended that research be continued to develop improved handling methods for foods including determination of optimum holding and transportation conditions so that product losses will be minimized and products will have top quality when they arrive at final consumption points.

In view of current interest in dietary fats, there is a need for development of means for producing unsaturated fats from saturated fats. There are several approaches to this problem. Among these are catalytic and biocatalytic methods.

The food industry needs rapid and least cost analytical procedures for the

determination of ingredients used in the formulation and manufacture of products. These methods would be helpful in controlling quality of finished products.

Fibers and Leather

Fabrics of 100% cotton fiber having durable or permanent press attributes are being introduced in the apparel market. Expansion of research is required to support this effort in order to improve the abrasion resistance, color and surface appearance retention and ease of apparel fabrication.

The reduction of processing costs is an essential element in the successful competition of cotton fiber in apparel and home furnishing fabric use. Continuous processing leading to automation in the several steps of cotton fiber collection and processing into yarn and fabric is a necessary step in the search for reduction in processing costs. In these areas and others resistance to soiling by air-borne soil and to spotting by spillage are attributes which will contribute materially to cotton fiber utilization. Continuation of the present effort is required.

The potential of added cotton use through improvement of its service attributes in use with synthetic and wool fibers should have added research support through explorations of changes in cotton properties in blends with synthetic and wool both in fiber blends and ortho-blends of yarn in fabrics.

The use of cotton linters and waste in nonwoven forms such as batting and resilient forms for home and industrial upholstering and bedding should be encouraged by continued effort.

In 1964 the 100% wool yarn production amounted to 477 million pounds of which 362 million were spun on the Woolen System and 115 million on the Worsted System. Up to now the problems in the manufacturing processes of woolen fabrics have not been investigated. Research on the mechanical processing of the Woolen System should be started.

Research should be expanded to explore all the possibilities to graft preformed polymers to wool fibers and their usefulness to improve the wearing quality of wool garments.

Modification efforts to increase or decrease the dyeability of wool should be resumed with the purpose of producing tone-in-tone or multicolor effects in piece dyeing of all wool fabrics.

It is emphasized again that wool fibers--the performance of which has been modified by various chemical and physical processes leading to new use attributes--should be studied as to their performance not only in fabrics using 100% wool fibers but in yarns and fabrics made up of blends of these modified wool fibers with cotton fibers and synthetic fibers. An example might be a blend of modified wool fibers with crosslinked or resin treated cotton fibers to determine if a completely washable no-iron garment can be achieved from a

blend of the two fibers.

Processing experiments should be started on the spinnability of 100% mohair, natural and modified.

Their is an urgent need for the development of a "least cost" type litter for use in poultry and livestock production. This is important to agriculture and the problem may be solved by scientists familiar with the properties of fibers and production of pulp for paper products.

Research in the handling of hides is essential to their preservation in commerce and protection from deterioration during the sometimes long collecting and hauling periods. It is suggested that studies be made of the techniques used in foreign countries, such as Australia, where major progress has been made.

The Committee recommends the continuation of efforts to develop new industrial processing techniques and the addition of polyfunctional chemicals which improve the service characteristics and will expand the market for leather products in apparel, home furnishings and industrial uses.

Industrial Products

Continued studies of the process for preparation of useful amylose starch film are recommended. Continuous processes for fermentation of cereals and/or starches would be very desirable and further work in this direction is encouraged. Also, further work on improved systems of degerminating cereals for industrial use of the endosperm portion is suggested.

As more basic information on composition of oilseeds is obtained, process applications become apparent. Particular consideration should be given to protein processing for preparation of meals, flours, concentrates and isolates. It is suggested that work be initiated on development of improved processes for the preparation of industrial type protein products. Technology in optimizing yields of exploratory products such as cyclic acids should be critically reviewed to determine practicality of further work in this area.

Technology to advance new crops into commercial use needs continued support. Kenaf for pulp and paper deserves further technical development toward practical production of paper and perhaps also toward overlays or surface components of architectural panels.

UNITED STATES DEPARTMENT OF AGRICULTURE
Research Program Development and Evaluation Staff
Washington, D.C.

REPORT AND RECOMMENDATIONS
of the
UTILIZATION RESEARCH AND DEVELOPMENT ADVISORY COMMITTEE
Developed at its Fourth Meeting
January 30 - February 3, 1967
Washington, D.C.

UTILIZATION RESEARCH AND DEVELOPMENT ADVISORY COMMITTEE

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Additional copies of this report may be requested from David J. Ward, Executive Secretary, Utilization Research and Development Advisory Committee, Research Program Development and Evaluation Staff, U.S. Department of Agriculture, Washington, D.C. 20250

PREFACE

The Committee reviewed the Department's cooperative program of utilization research and development. It considered annual Progress Reports and other resource materials describing research activities. National research leaders briefly described research and development programs, discussed some accomplishments and defined important needs. Scientists of the Eastern Utilization Research and Development Division and the Human Nutrition Research Division, Agricultural Research Service, gave several on-site demonstrations of research underway, including procedures and facilities. They also discussed achievements and problems yet to be solved.

Dr. G. L. Mehren, Assistant Secretary and Director of Science and Education, is Chairman of the Committee. Dr. F. R. Senti, Deputy Administrator for Utilization and Development, Agricultural Research Service, is Vice Chairman.

Milton Harris was unable to attend the meeting.

CONTENTS

COMMENTS AND RECOMMENDATIONS

GENERAL

World Food Program

Pronouncements by the Executive Branch of the Government of the United States have made it very clear that this country has a vital stake in the food problems of the world for many diverse reasons. This carries with it a responsibility not only to continue programs of exporting food to supplement the total supply existing in food-deficient areas, but also to export technology which will enable these areas to become self-sufficient in the means of providing food for their populations in an orderly progression of developments. One of the primary goals will be the utilization of all potential sources of food, which obviously will differ as to geographical region. Some of the necessary technology is available. Much needs to be done.

Research should be conducted to define the nature and extent of the food problems in specific geographical regions and to delineate food preferences, taboos, etc., for target areas.

One of the critical needs in many areas of the world is an increased supply of protein, preferably of high quality. Utilization research will be urgently needed to permit efficient use of oilseeds, legumes, amino acid supplementation, and less conventional sources of protein. Soybeans, without doubt, could be a major source of this vital nutrtional material. While much is known of the properties of soybean proteins, soybean flour and full fat soybeans, additional work will be needed to permit their use in various types of food products and to insure their acceptability by widely diverse peoples.

Since protein malnutrition or undernutrition are critical problems in many food-deficient areas, it is evident that all sources of protein must be utilized, with particular emphasis on indigenous sources. Processes must be developed which will result in the production of suitable protein concentrates from cottonseed with low free and total gossypol content and with minimum reduction of available lysine content. Practical and economical methods for removal or destruction of aflatoxin must be provided. Peanut protein products must also be utilized as fully as possible. These must be fully protected to preclude the occurence of possibly injurious levels of aflatoxin.

New sources of protein need to be investigated and research should be started immediately to determine the feasibility of producing protein by the growth of bacteria, yeasts, fungi, algae, or other simple organisms, preferably using substrates which are not presently utilized as human food. This may include the use of agricultural wastes, petroleum products or other materials. Utilization research should be actively engaged in this type of work and certainly should keep abreast of developments in this area. Foods for both animals and humans might result from this work.

Much protein in leaves is being wasted. The recovery of protein from this source would not only enhance the total protein supply, but would help reduce agricultural waste in food processing. Research in this area would provide technology for the recovery of protein from leaves throughout the world, particularly in tropical areas where foliage is abundant the year round.

The foregoing recommendations indicate the role utilization research should be taking in the production of protein products to help solve world food problems and in implementing presently stated U.S. policies. However, these recommendations apply equally to research directed toward domestic needs, albeit with less urgency attached to the solution of these problems. If, in the face of an increasing population, our existing high standard of dietary excellence is to be maintained, new sources of feed for animals and new methods of adapting plant materials for human foods must eventually be found, and wastes from food processing must be minimized. Therefore, for both domestic and worldwide applications, these new food and feed areas should be explored as a part of the utilization research program.

New economical protein sources acceptable in terms of texture and flavor need to be developed. Study of flavors has lagged until recent years because of the lack of scientific equipment for their ready isolation and identification. Such is no longer the case, and a productive research effort on flavors is now feasible as well as timely.

As the use of processed and packaged foods increases in our nation and the world, it becomes of greater importance that standards be established for the selection and use of packaging materials insofar as they affect product stability. Greater emphasis needs to be placed on the evaluation of packaging materials and the determination of criteria and standards for their performance so as to provide improved and extended shelf life for foods.

Research on foods should include fundamental studies of the cellular morphology of the principal grain and oilseed products. A knowledge of the detailed biological structures and the corresponding chemistry could lead to more rational approaches to the processing and economic utilization of such crops. Similarly, a greater knowledge of the cell wall structure and enzymology of fruits and vegetables could lead to better preservation of such properties as texture, flavor, and moisture content during harvesting, processing, shipment and storage.

National Research Program

The Committee commends the Department of Agriculture and the Association of State Universities and Land Grant Colleges for the successful completion of the survey of agricultural research efforts and projected needs with the publication of the report, "A National Program of Research for Agriculture." This provides a thorough analysis of expenditures in terms of manpower as well as money and provides guideposts for the direction of future efforts. This has been a difficult assignment, which has been handled well and with

dispatch. The committee in charge is to be commended for the inclusion of information from the agricultural industry in these compilations, which certainly enhances the value of the statistics.

Prior to the post World War II era, a major portion of Federal support for research and development was devoted to agriculture. This pattern changed markedly as support for other aspects of science increased manyfold. The funds allocated to agriculture research and development now comprise an extremely small percentage of the total Federal research and development effort.

Agriculture and related industries are mainstays of our economy. They are assuming increasingly significant roles in international affairs. It is strongly urged that support for agricultural research be increased commensurate with agriculture's contribution to our gross national product and the urgent political and humanitarian needs for assisting in finding ways to feed, clothe and house the world's burgeoning population.

Utilization research will play an important part in accomplishing the goals of agricultural research as stated in the above report. Without strong programs of product development and quality improvement, which are the essence of utilization research, it will not be possible to realize the full potential of those projects concerned with increasing our total productivity. Furthermore, achievement of those goals concerned with health, standards of living, and environment will also depend on progress in product and quality research. Thus, utilization research will play a key role in accomplishing the stated goals. Recognition of this role and appropriate financial support of an expanded program are therefore strongly recommended.

It is recognized that there are limitations of manpower, available money and other resources which prevent meeting all of the needs of research during any given period of time. Without deemphasizing the ultimate need for all of the recommended research, priorities must be established in light of competition for resources within the total effort. Therefore, the following priorities are recommended:

1. The level of utilization research effort in the area of foods and nutrition must be increased. Longer range problems deserve particular attention.

2. The level of effort in improving wholesomeness and safety of human food products must be increased.

3. The level of effort to salvage and utilize currently wasted food values must be increased. Losses of 20 percent or greater from production to consumption cannot be tolerated.

The National Program of Research for Agriculture provides very useful guidelines for both administrators and program planners, but such studies must be reevaluated frequently if they are to be useful over a period of years.

Changing conditions dictate shifts in direction of programs, and timetables must be restudied regularly to avoid wasted effort.

The survey indicates, in agreement with other sources, that the cost of research has been increasing and is projected to continue to increase at an approximate rate of six percent annually. On this basis, utilization research shows an actual decrease in level of effort for fiscal year 1967, and only modest increases in manpower and dollar projections for the five and ten year programs. This would not be adequate to staff and operate new facilities now being constructed.

Programs directed toward the improvement of the welfare of the people of this country are doomed to complete failure if the supply of good, wholesome food fails to keep pace with the increased population. It is strongly recommended that the projected allocations of manpower and dollars be reevaluated in this context, and that the level of the utilization research effort be increased commensurate with the needs.

Air, Land and Water Pollution Problems

Agriculture has a very definite responsibility for control of pollution in our environment. Agricultural practices can be causes of pollution or aids in the abatement of pollution. Agricultural industry may also be a victim of pollution. Utilization research has a responsibility for the development of many food and feed handling and manufacturing processes, some of which inevitably lead to the production of waste products which may pollute land, air, or bodies of water. It has the obligation to develop as complete a use as possible of all components of the starting materials, including recovery of by-products, in order to prevent waste and avoid pollution, and these factors must be a part of the evaluation of new processes. Constant reappraisal of existing processes should be an integral part of the utilization research programs, not only for profitable recovery of waste products, but also for abatement of pollution.

Basic and Exploratory Research

It is recommended that greater effort be devoted to fundamental studies of the biology and chemistry of important agricultural products in order to increase our detailed understanding of them and thereby bring to light new ideas for their utilization. For example, more knowledge is needed of the factors which cause physico-chemical changes in proteins such as gel formation, heat coagulation, etc. Studies of this sort should not require justification on a dollar basis although fundamental knowledge is of material benefit in the solution of practical problems. Similarly, exploratory investigation of potential new crops should be encouraged and should not be deterred by apparent lack of immediate utility.

Industrial Utilization

New industrial applications for the principal fractions of agricultural products--starches, proteins, and oils, for example--deserve continued

attention and should be pursued to the extent that such applications make use of characteristic physical or chemical properties of the initially derived materials. Usually only minor chemical processing can be justified. Multistep chemical processing to convert agricultural products into close analogs of current industrial chemicals and plastics is usually unrewarding. Work of this type is discouraged. Where pure chemicals of complex structure are readily isolable or easily derived from agricultural products, they should not be made the basis for extensive studies, but should be made available as candidate starting materials for traditionally high-priced products such as insecticides, specialty functional fluids, flavoring agents, and pharmaceuticals.

Research Management

The efficiency and productivity of utilization research could be greatly increased by improving the exchange of information and ideas among the four Divisions. The aflatoxin project, for which good interlaboratory relations were established, demonstrates the value of closer cooperation. Progress on the important aflatoxin problem was far faster than would have been possible if each laboratory had been studying the problem alone. There are many additional research areas of common interest to the Divisions, and it is accordingly recommended that there be established small working teams or "specialist groups" which would bring together representatives of those laboratories having research interests in the subject areas. One man should be selected to represent each laboratory for each area. For example, there might be one specialist group for flavors, one for mycotoxins, one for human nutrition, and so on. These groups would not need to meet often. Once or twice a year should suffice. There existance, however, would facilitate the planning of cooperative projects and the exchange of suggestions and information on scientific progress and techniques.

Current policies toward travel of technical personnel should be liberalized to make possible the interlaboratory cooperation proposed above. Travel policy should also be modified to permit greater advantage to be taken of scientific society-sponsored meetings as a means of promoting information exchange between Department personnel and members of the industrial and academic communities.

Evaluation of projects is inevitably a very important feature of the evaluation of the scientist conducting the work. Research management needs to be alert continually to the tendency to continue projects beyond the proper time of termination. When publications are the prime consideration in the appraisal of scientists for the purpose of promotion or salary increases, there is a very real danger that the publications rather than the solution of problems or the effective use of manpower and facilities become the goal. Results obtained, ingenuity used in the approach to the problem, dedication of the scientist, and similar criteria are far more important than numbers of publications in evaluating the work of scientists.

An important duty of research management is the termination of projects which, in the light of increased knowledge, do not appear as attractive as they did

at the time they were started. There should be a continual critical evaluation of projects with the objective of assigning personnel to the most promising and productive research areas. Even certain technically successful projects of applied research should be terminated, after a reasonable period of time, if the demonstration of feasibility has not brought about industrial acceptance.

The Department has made good use of outside contracts and grants in extending its capabilities. The Committee particularly recommends this procedure for implementation of projects which require specialized technical competence, equipment, or facilities which are not available in Department laboratories and which would be difficult to acquire rapidly or for which there would not be a continuing need. On the other hand, since there will be a continuing need for nutritional and toxicological studies, it is recommended that those major Department laboratories not equipped to utilize small animals in their research take steps to provide appropriate facilities, hire trained personnel and initiate such studies in support of ongoing projects.

Sugar Research

Utilization research on sugar was terminated in fiscal 1966. This is an important and significant domestic farm product. Much still needs to be known about the composition and effect of nonsucrose components on processing procedures and about correlations of composition with processing quality to provide guidelines for new processes and varieties aimed at improving the economics of sugar recovery. Research studies should include investigations into possible new and useful by-products, including products for uses other than foods. The Committee highly recommends reinstitution of compositional studies in the area of sugar producing crops.

CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES

Foods

A detailed knowledge of the chemical composition and physical properties of processed foods, and the raw materials from which they are made, is essential to the development of new and improved processed products and to the improvement of processing technology. Research should be continued on major and minor components, their structure and properties, and changes that occur during processing.

Raw materials should be studied with the hope of identifying principal factors that will make animal, oilseed and cereal products more useful in the preparation of processed foods and food ingredients. We need to identify the various protein fractions in cereals, oilseeds, meat, milk and eggs to determine the role that each constituent plays in the formulation of food products such as sausage, bread, cheese, etc. A far more complete determination is needed of types of protein, protein level, and amino acid content for these raw materials, particularly the differences that may exist in different cuts of meat within the same carcass, from carcass to carcass within the same species, and in

the principal varieties of grains, oilseeds, fruits and vegetables. Similar information is needed for milk and eggs.

Prerigor meat binds moisture and fat more effectively than chilled or frozen meat. It would be valuable to determine the factors responsible for imparting this characteristic to meats. This information would be useful in efforts designed to preserve or impart this particular desirable characteristic in some chilled meats used in fabricating products. More information is necessary on the chemistry of pork and beef muscle pigments from the standpoint of imparting the desirable color in both fresh and cured meats. Information is lacking on the quantitative aspects of the reactive pigments.

Expanding the use of poultry meat for items such as luncheon loaf, sausage or rolls is limited by a lack of information relating to the processing characteristics of chicken and turkey tissues. Detailed information on the reactions and interactions of the various components of these tissues is needed. The increased utilization of egg products will depend upon our knowledge of the chemical properties of egg yolk and egg whites. These properties determine the functional value of eggs when used in fabricating food products. The effects of processing treatments, such as freezing, pasteurization and dehydration on the functional properties such as viscosity, emulsification and leavening ability will be better understood as more compositional information is obtained. The effects of modifying egg components by chemical, enzymatic and physical techniques to improve performance should be further studied.

The Department is commended for its excellent work in the field of composition and physical properties of milk constituents. Of special significance is the work on the identification and properties of the various casein fractions in milk and the attempts being made to characterize the behavior of these substances under various processing conditions. The P.L. 480 grant program and those domestic grants and contracts activated in this area appear sound and should yield much needed basic information. There is, however, a strong need for more work dealing with the behavior of dairy ingredients (natural or modified) in processed foods, dry mixes, bakery products and confectionery items. Milk components behave quite differently in association with non-dairy ingredients than they do in their native system. Such behavior or interactions must be understood so that broader applications of milk ingredients can be made possible in modern food technology. Increased attention is being directed toward enzyme systems in dairy products. Isolation, purification and assay techniques appear to be lacking and there is evidence that enzyme systems play a part in flavor changes of some stored dairy products. A modest program of investigations in this area appears to be warranted.

There is an insufficiency of knowledge on the chemical composition and properties of proteins of seeds and seed-derived protein products for food. This area of endeavor should be substantially expanded to provide a sound basis for the development of new and improved protein ingredients which provide both nutritional value and functional properties necessary for the fabrication of a variety of acceptable food forms. It is recommended that

these investigations encompass, among other aspects, both major and minor protein components, amino acid composition, molecular structure and association, and changes in molecular structure and composition arising during production of derived protein products and during fabrication into food forms. It is important that attention be devoted to varietal differences in the nature of the protein components of seeds and to differences within variety as influenced by climatic and soil conditions. Means for modifying the functional properties of seed proteins are needed to provide characteristics which are useful in various food systems.

Vegetable carbohydrates are important constituents in numerous natural and manufactured food products. They contribute functional properties and nutritional values. It is recognized that more information is needed on the relationship between composition and functional properties. Also, study of the relationship of carbohydrate composition and associated factors of oilseeds to their physiological activity should be continued.

With the growing need for stabilizing perishable fruits and vegetables in order to minimize the adverse effects of seasonable surpluses and unfavorable markets and to convert them into a usable form for attractive convenience foods, more information is needed on their chemical composition and physical properties. Research studies should be intensified in relating compositional variations to successful mechanical harvesting techniques as well as to improved preservation methods such as liquid nitrogen freezing, freeze-dehydration, reverse osmotic dehydration, etc. These studies should include the development of a better understanding of the behavioral habits of enzyme systems and the effective useful control of enzyme activity in all phases of utilization.

Feeds

To improve the computer formulation of mixed feeding rations for farm animals and poultry, there is an urgent need for accurate and systematic data on the composition of feed grains, oilseed meals, forages, roughages, and animal products for feed. Such data must include the basic constituents, such as protein, fat, fiber, essential amino acids, vitamins and minerals. In addition, there is need for reliable energy values. It is important that these data provide information on both average values and range of values on commercial products. Their acquisition will require the evaluation and development of reliable analytical methods and sampling procedures.

There is continuing need for rapid chemical or biological methods to assess the nutritional availability of limiting amino acids in processed protein products for feed. Although much progress has been made in determining the availability of lysine, it is equally important that studies be undertaken to develop rapid methods for evaluating the nutritional availability of other essential amino acids. Such work must include a study of the range of utility of these methods as applied to a diversity of protein products used for feed.

In order to improve the value of agricultural crops for feed, it is recommended that fundamental investigations on the physical, chemical and biological properties of major and minor constituents and interaction of these constituents with other nutrients be emphasized. It is necessary that these studies on properties be related to nutritional value for farm animals and poultry. Changes in the nutritional value of components as a result of storage of both agricultural crops and feed ingredients processed therefrom should not be overlooked. Further, an understanding of changes in these components during processing can provide valuable clues to improved processing methods.

It is recommended that an investigation be made of the nutrient composition of new strains and genotypes of feed crops such as triticale in order to provide a basis for the development of new or improved feed ingredients.

Fibers and Leather

This particular category of farm products, including cotton, wool and leather, from all predictions will be relegated to a lesser consideration in our national merchandising. A gradual attrition from the inroads of man-made synthetics affects each of them. This year by year attrition becomes most apparent when the past performance and future predictions of synthetic products are considered over a ten-year span.

Basic research into the chemical and physical properties of fiber and leather provides ideas for new and improved products. The Department's effort, particularly in these basic areas, has achieved a national and worldwide reputation for excellence. It is well to note that this basic research is difficult, costly and time consuming, without the benefit of readily usable results such as obtained from product development technology.

The Committee again emphasizes that the chemical composition and physical property determination aspect of utilization research should be kept at the present level of effort as a major portion of budget expense.

Cotton

More knowledge is required on the properties of a resilient cotton without crosslinking. Studies of effects of swelling in all stages of manufacture and end use swelling requirements studies should be continued and accelerated. Vapor phase permeation and pore size determinations, along with mechanism and rate studies, are encouraged and should be continued. Solvent chemistry is becoming a part of textile finishing and research should be initiated.

Fiber dynamics studies in air, in electrical force fields and under the influence of ultrasonic energy sources are necessary and should be accelerated.

Wool

Basic investigation on the chemical breakdown occurring in the proteins of wool and mohair as a result of exposure to sunlight and weather during their growth and to heat and chemicals in processing them from the raw to the finished

cloth should be our aim. The result should provide sources of the needed knowledge on the nature and location of the reactive centers in the wool molecules, to which modifying chemicals might be attached to improve wool properties and create new types of wool fabrics.

Leather

Knowledge of the basic chemical and physical structure and microscopic investigations of leather should be extended.

There are natural qualities of leather which are being imitated by synthetics. These should be clearly defined and attempts made to improve them through basic chemical and physical knowledge.

Industrial Products

Cereals

Cereals represent the largest volume crops available for industrial utilization. Furthermore, the price per pound of starting material is low. It is recommended, therefore, that work on the composition and physical properties be continued especially on corns, wheats, and sorghums. Additional data is needed on the minor constituents of these cereals. An important contribution would be preparation of a critical summary of data already available on composition and physical properties of corn, wheat, rice, oats and sorghums.

Recent evidence that genetic changes in the corn plant influence the amino acid composition of the grain protein emphasizes the point that we need to expand considerably our knowledge of compositional effects of genetic changes in all cereal crops. Such changes can affect significantly their industrial utilization. Likewise, cooperative analytical work and plant breeding work on high amylose corn should be continued toward the development of high amylose corn for industrial use.

Oilseeds

Industrial use of the various major and minor oilseeds implies a need for continued surveillance of both new analytical or instrumental techniques and of variations in old or new oilseeds to keep them useful and competitive in an advancing technology. The Utilization Research and Development Divisions are to be commended for their continuing competence in the oilseeds within their jurisdictions. There is need to continue the search for compositional variants in these oilseeds and their components to lead to new industrial uses.

More detailed knowledge of the chemical and physical structures of the proteins in soybeans, cottonseed and other oilseeds could lead to improvements in their modification or fractionation for better adhesives and other industrial purposes. Disposal of by-products and water effluents from protein isolates needs more detailed understanding of composition for better by-product values and simpler waste disposal.

Linseed and other oils used in paints suffer increased competition from synthetic polymers. More knowledge of the chemical details of the successive steps in the degradation of a film of paint should lead to improved processing to make the oil even more valuable in paints. Current publications on use of attenuated infrared reflectance and on chromatographic measurement of volatile products of decomposition induced by actinic light, moisture and air are indicative of more work to be done in this area.

Chalking of paint, as a function of pigment wetting and pigment-vehicle chemical interaction, deserves more minute examination. Color acceptance in the tinting of water-based vehicles from linseed oil is a factor in marketability which relates to the composition of the processed oil and the oil's chemical relationship to the surfactants and thickeners added in water-based paint systems.

Composition studies on new oilseeds and new varieties of old ones, e.g., sunflower seed, should continue. The paint industry has a continuing need for drying and semidrying oils which are high in linoleic acid, low in linolenic acid and have low color-forming constituents. Work should continue toward finding economic sources of hydroxy containing fatty glycerides and epoxy types.

Naval Stores

Naval stores is a relatively mature industry, with composition and properties of its chemical components sufficiently well known that new work thereon should be limited to elucidating new processes for their production, or newly important sources. Chemical reactivities of components need further work commensurate with general advances in chemical science and technology. Particularly, new sophisticated analytical devices should enable the more accurate and detailed measurement of the successive chemical steps in the degradation by light, air and moisture of the several, common isomeric acids in rosin. Increasing competition from other materials for the major end uses of rosin imply a continuing need for more detailed understanding of the vulnerability of rosin in these end uses. Associated with this is the need to improve the properties of whole wood from which rosin is derived, e.g., the liability toward end uses of southern yellow pine due to the resin streaks therein. Details of these points in the 1966 recommendations are reiterated.

Of the two general components of pine gum, the family of terpenes is in better balance of supply and demand. Composition details are well elaborated, and a number of promising, sophisticated uses have been developed. Therefore, little or no further work is needed on their composition, physical properties, and general reactivities. The other major component, rosin acids, whether from pine gum, stump recovery or paper pulp production is likely to face mounting over-supply and needs a carefully thought out program to find new, sophisticated uses for this unique class of chemical compounds. Competition in paper coatings, paints, etc., from polymers based on simple vinyl compounds such as styrene, acrylate esters, and from other materials leaves rosin economically vulnerable. Lower costs and greater supplies of phthalic anhydride,

trimellitic anhydride and related polyfunctional monomers makes more difficult the planning of a research program to understand the chemical weaknesses and strengths of rosin acids. The relatively high starting cost of rosin as a base for chemical synthesis sharpens the need for more sophisticated improvement.

New Crops

Analytical work on chemical composition and physical properties is the key to the search for new crops having industrial applications. Screening of plants as a source of pulp fiber and of new industrial oils should not only be continued but expanded to include a search, by means of compositional studies, for possible plants to produce other needed industrial raw materials such as special starches, polysaccharide gums, insecticides, enzymes, plant pigments, and pharmaceutical precursors. The commendable work done to date should be expanded considerably in order to evaluate more of the large number of plant specimens now available. The new analytical tools and methods should make this project productive of several new crops.

Tobacco

The major questions to which utilization research and development efforts on tobacco are now being directed relate to the adverse associations that have been made between the use of tobacco products and certain health problems. The economic implications of research which may lead to definitive answers and to means of favorably resolving such questions are of such magnitude that a continuation and expansion of work is indicated on all fronts that are judged to have promise of making significant contributions.

"Over association" or unwarranted association of the results of investigations with the health controversy can be quite detrimental to progress in the area of tobacco research. In that studies at the Utilization Research and Development Division laboratories have served as models of good scientific investigations, well and accurately reported, it is of especial importance to the broad front of the tobacco research area that special precaution is taken to see that association of findings with the health controversy be made only when such association can unquestionably be substantiated.

In addition to research and development work directly related to the health controversy, there is need to identify and better understand natural occurring and processing factors which influence flavor and which affect ageing and fermentation processes. Similar knowledge is needed on smoke composition and the differences that arise with tobacco varieties and new strains. Such information may be of major importance to the study of modifiers and to the development of varieties and strains having desirable characteristics.

In that promising directions of utilization research and development were carefully outlined in the January 1966 recommendations and the essential features remain applicable, these recommendations are briefly restated. Areas which deserve continued and increased effort include (1) elucidating the physico-chemical mechanisms of smoke formation and formation of smoke components;

(2) associating precursors in tobacco with smoke components; (3) quantitative analysis of some significant chemical fractions which as yet have not been adequately resolved; (4) improving and developing analytical methods for tobacco and tobacco smoke constituents; (5) identifying, in the several varieties of tobacco, the major chemical entities responsible for aroma and flavor and of factors which enhance desirable aroma and flavor; and (6) identifying the tobacco constituents which undergo significant changes in the ageing and fermentation process and relating them to smoke components.

A few items deserving special mention, either for emphasis or for other reasons, are discussed in the remaining paragraphs.

The development of exceptionally efficient analytical methods for determining major and minor components of the various chemically and physically separable fractions of tobacco and tobacco smoke deserve a continued high priority in utilization research and development. Quantitative identification of chemical entities native to tobacco which are transferred directly or serve as precursors of smoke components is essential to any systematic investigation of flavor, ageing, etc., as well as to possible relation of specific substances to the health controversy question and to methods of modification or elimination of particular components that may later be indicated.

A particularly important tool that has been too little used in tobacco smoke investigations deserves specific mention, namely, the tagging of specific leaf constituents by mass or radioisotopes and subsequent determination of the form in which the constituent or fragments of same appear in the smoke. A major contribution to utilization research concerning smoke precursors could be made by systematic investigations using such methods.

The use of modifiers to effect a lowering of combustion temperature appears to suffer from the lack of a meaningful and well established reason for achieving such a temperature lowering. A more useful direction of effort would be a careful determination of the isothermals and chemical composition which characterize the heated section of the tobacco column during the free burn and "puff" period. Modifiers should then be examined in terms of the physico-chemical properties of the modifier and the effect of such modifier on the character of the isothermals. Extensive analytical work on smoke constituents is a necessary and integral feature of determining the significance and efficacy of possible modifiers.

The study of pyrolysis products of tobacco and tobacco constituents may considerably simplify analytical identification of some substances which may be present in smoke. The significance of such studies will be limited in at least two ways, the first being that quantities obtained may bear no relation to those obtained in the actual smoking process and the second that substances may appear which are not produced, or are not produced in the same fashion in the smoking process. The significance of such studies will be greatly increased if volatility and thermal degradation characteristics of the tobacco constituents and the relation of these to the cone region isothermals and the time characteristics of the isothermals are programmed into such investigations.

The physico-chemical mechanisms of smoke formation and formation of smoke components deserved immediate and continued investigation as the elucidation of the thermodynamic and kinetic processes will be essential to a full understanding of the smoking process and thus of the methods by which the process can best be modified if the need arises.

The continuous liaison of representatives of the USDA utilization research and development effort with research representatives of the tobacco industry will be of great benefit to the total tobacco research effort and should be encouraged.

FLAVOR

Because of its fundamental importance to food acceptances, the gradual expansion of the flavor research activity is commended. However, there appears to be several areas of flavor research which justify sharply expanded effort. With the greatly improved instrumentation and methodology available to the flavor chemist today, progress in this area can be greatly accelerated.

The programs of the Department are yielding very useful information on the natural and "off" flavors that occur in milk and certain milk products. The work should be greatly expanded in the fields of evaporated and other sterile milks as well as in dry milks. The problems appear to be most critical in the area of flavor preservation during storage and distribution. It is felt that this problem may become more critical in the years ahead when milk production and processing may become concentrated in areas quite distant from the centers of population.

The Department of Agriculture is to be commended for its contribution to the flavor improvement of soybean oil. In spite of the years of effort devoted to this problem, it should be understood that the use of soybean oil as a cooking and salad oil and its use in margarine as a liquid oil is limited because of flavor instability. The Committee recommends that selective hydrogenation for improvement of stability be singled out for concentrated effort to determine as quickly as possible whether this approach affords a practical solution to the long standing problem. This recommendation is based upon a recognition of a need for more urgent effort on the flavor qualities of other soybean fractions.

The food utilization of protein products derived from seed sources, such as soybeans and cottonseed, has been restricted because of undesirable or unwanted flavors associated with these products. It is imperative that effort in this area be expanded and intensified. This effort should include both basic and applied studies on the characterization, alteration and elimination of the undesirable flavor components or flavor precursors. It should be recognized that this tudy in depth must encompass unwanted flavors formed during the processing of the protein ingredients for food and those undesirable flavors arising during the processing of composite food items as represented by typical complex food systems.

Food products are being prepared from ingredients that may impart no well defined or characteristic flavor to the manufactured food items. These foods may be made from disassociated meat fibers, from highly processed plant materials or from synthetically produced ingredients. To meet consumer demands and requirements in many instances it will be necessary to add suitable flavoring materials. Many new meat and poultry products are being developed which lack characteristic flavors. A search for additives that impart or enhance desirable flavor characteristics of foods is encouraged.

Investigations currently underway relating to the flavor of meat should be expanded. The chemical components which collectively determine aroma and flavor are being identified. The results of these studies might at some future time permit the meat flavor to be duplicated by the assembly of synthetically prepared flavor components. This general approach to the flavor problem should be expanded to cover a wide variety of foods.

There are many unanswered questions concerning the influence of packaging, storing and processing of meat on its flavor characteristics. Additional investigations are urgently needed to determine the factors responsible for "warmed-over" flavors which characterize so many precooked convenience foods.

Commendable progress has been made in the area of identification of flavor components of fruits and vegetables and in the changes which occur in these flavor components during processing. The Committee recommends increasing the effort in this research work in view of the significant problems encountered in the loss of desirable flavors and development of undesirable flavors in processed fruits, vegetables and other plant products. More reliable methods should be developed for the correlation of subjective methods of flavor recognition with the increasingly refined objective methods of measurement.

Development of undesirable flavors during storage of dehydrated tomato products has limited their use in formulated convenience foods. An understanding of the nature of these flavor changes could offer a clue to stabilization techniques and thus increase the wider potential utilization of the product. Similar flavor instability problems occur with other fruits and vegetables.

To improve the quality of processed potatoes, ways must be found to enhance and retain the desirable natural flavor of freshly cooked potatoes and prevent or eliminate the frequently encountered stale, earthy, rancid, green and warmed-over flavors in processed potatoes, including dehydrated mashed potatoes, dehydrated diced potatoes, frozen french fries, frozen patties and potato chips.

Basic investigations should be initiated on the mechanisms of the biosynthesis of flavors in fruits and vegetables. The role of enzyme systems in the development of flavor constituents from precursors should be a fundamental aspect of this basic study. By understanding the mechanisms involved, better control of desirable flavor development and stability can be attained. With improved techniques and methodology, investigations should be continued in isolating and identifying new flavor components in animal and plant products.

COLOR, TEXTURE AND OTHER QUALITY FACTORS

The Committee recommends that more emphasis be placed on color, texture and other quality factors of foods and food ingredients since these factors, together with flavor and aroma, are of prime importance in establishing and maintaining consumer or user acceptance.

Increased emphasis should be given to studies on methods for imparting desirable quality properties to food protein products and to protein-rich foods designed for food-deficient countries.

It is evident that the exposure of dairy, oilseed, and cereal products to heat, moisture and other factors in processing can bind or destroy substantial portions of lysine, and perhaps other essential amino acids such as methionine and threonine. The Committee again recommends that research be initiated to develop rapid chemical or biological methods for evaluating the nutritional availability of essential amino acids, other than lysine, and to explore the influence of processing conditions on their biological availability.

The Committee supports the work in progress on the evaluation of oilseeds and legumes and products derived therefrom as sources of digestive disturbances, particularly flatulence in sensitive individuals, with the recognition that this is important for full utilization in foods for infants and adults. This work must be continued to identify the responsible agents and to devise methods for eliminating or inactivating them by practical processing methods.

Studies should be made of the natural pigments of poultry meat and their modifications during processing. The influence of added ingredients on the behavior of pigments in further processed products should be investigated. The sporadic occurrence of unnatural pink color in cooked turkey meat products indicates the need to identify the chemical composition of the pigments involved, with the hope of eliminating this problem. Under present continuous-line processing procedures, optimum tenderness does not develop in a small but significant percentage of birds. One approach to this problem is the development of a means for rapidly identifying tough birds during processing so that they can receive special treatment. Basic studies on tenderness should be expanded by emphasizing the mechanism of tenderization and the processing factors that are responsible for the lack of tenderness.

Egg quality at the consumer level has not improved to the extent that is desirable. It is difficult to handle eggs correctly at all levels. It is suggested that attention be given to the development of improved processing techniques to reduce the number of checks, cracks, leakers and dirty eggs. The information obtained must be effectively distributed to all handlers.

We have no way of estimating the true losses due to impairment of quality because of defects in agricultural products. These losses occur not only in poultry and eggs but in all livestock and in all foods such as grains, fruits, and vegetables. The defects may be of genetic origin or may be due to a lack of nutritive balance during growth and development. Harvesting, transporting,

processing, storing, weather, weeds, insects, rodents, and disease may be responsible for quality impairment. As the demand for food increases, it becomes increasingly important not only to produce foods of top quality but also to protect this quality at all times.

Recently there has been considerable interest in centralized meat cutting and packaging. Present estimates indicate that these centralized operations would require time in distribution channels beyond the normal shelf life of the product. Research is needed on methods of pasteurization and pigment stabilization which would extend the shelf life of retail packages to 10 to 12 days without detracting from meat quality. A certain amount of basic research should be part of this project since many sources of variables in the shelf life of a prepackaged meat are still a mystery. For example, it is often observed that some meats with very high microbial counts are organoleptically quite sound while others with relatively low counts may be unpalatable. Research in the bacterial ecology of prepackaged meats has not been sufficiently rigorous to explain this anomaly.

Research should be expanded to provide basic knowledge about color, texture and other quality factors of raw materials to provide a base for new food product and process development. Examples of such needed research include (1) determining the effects of wheat flour and dough constituents on the rheological character of doughs and on their baking qualities, (2) characterizing fruit and vegetable pigments and developing methods for stabilizing the bright natural colors of fresh produce, and (3) determining how to overcome problems of varying color and texture which result from mechanically harvesting fruits and vegetables at varying stages of maturity.

Fundamental studies with respect to enzyme activity and other factors as they apply to plant and animal products in the areas of color, flavor, texture, tenderness, and moistness should be expanded. Also, the study of factors influencing the textural qualities of frozen and dehydrated fruits, vegetables, and meats should be expanded. A better understanding is needed of the factors which contribute to turgor of fresh fruits and vegetables. Studies of means of retaining turgidity in (1) frozen products after thawing and (2) dehydrated products after rehydration should also be expanded. In this area, improved methodology and the development of basic concepts of the structural units responsible for texture that meet consumer preferences are needed.

MICROBIOLOGY, TOXICOLOGY AND FERMENTATION

Enzymes

The Committee has recognized the great potential of enzymes as means for the developing new and improved food ingredients and processed food items. In emphasizing the need for expanded research in this area, the Committee refers to its last report.

Nature has provided a vast array of agricultural products for man's use. In the plant, animal or microbial organisms which produce these products, the

composition and physical characteristics are determined by catalysts which control all life processes. These catalysts are complex organic molecules that can be recovered from natural biological systems, identified and, in turn, used to promote specific organic chemical reactions. Since enzymes, as these catalysts are called, are specific and capable of directing complex chemical breakdown or synthesis of products, they have potentials far beyond our present simple utilization of them.

The Department is to be commended on the important role it has played in elucidating enzymatic reactions and in employing still others to produce important products. Its scientists now use enzyme reactions in many developments, such as in hydrolysis of starch to glucose and in preparation of polysaccharide from glucose. In fact, this is an example of enzymatic breakdown or hydrolysis of a large carbohydrate molecule (starch) of one type to simple glucose units with one enzyme system. Then, another enzyme system is used to synthesize from the glucose a large carbohydrate molecule of a different type. Other systems exist for protein alteration, antibiotic production, chemical manufacture, etc.,--all using agricultural products as raw materials. Many other specific and unstudied enzyme systems are available in the USDA culture collection, which is the greatest assembly of microbiological specimens in the world. This collection must be "maintained" and expanded.

It is recommended that serious consideration be given to severalfold expansion of fundamental studies on microbial enzyme systems. Such work requires a high level of scientific effort, but the potential value is unlimited. The resource material is available. The work with agricultural products is not being done elsewhere in the world. The USDA should have the necessary scientific and financial support. Among the objectives are (1) develop fundamental knowledge of enzyme systems; (2) learn to control them in the curing and processing of natural food, feed, and fiber products; (3) isolate and produce enzymes or enzyme systems for specific reactions; and (4) develop new and useful food, feed, and industrial products using them. Closely allied to these is extension of the work on "breeding" of new microbiological lines. A program is suggested to study microbial genetics with the view toward developing new cultures which have specific functions or enzyme systems.

The proposed enzyme research is indeed a long-range project, but many useful products or processes would be derived early. Their number and importance would be expected to multiply rapidly as scientific advancements build one upon the other in this field. Results of the work would apply to all commodities and crops. In its early development, this research could be done most effectively and efficiently by assembling the world's best talent in this field at one location and providing them with the proper scientific equipment to do the job.

Foods

The overall manpower inputs of the Department in the microbiology and toxicology fields are regretfully inadequate. With the greater awareness and attention being given to the general field of food protection, it behooves all segments

of industry and government to identify and correct the many obvious points of contamination confronting the food industry today. It is urgently recommended that the Department review its entire program in this area and initiate and expand its studies which relate to the microbiological contamination of food products and its ultimate effects on market quality and public health.

Of particular and immediate concern is the elimination of Salmonellae contamination which is currently confronting many segments of the food industry. Research is needed on the growth, survival and death of selected Salmonellae types under a variety of conditions of temperature, humidity and hydrogen ion concentration in foods. Special attention should be given to processing procedures designed to reduce contamination and destroy microorganisms which may be present in finished dried products.

Attention is again drawn to the question of heat resistance of spores in processed foods and food ingredients. The presence of spores in many processed foods limits their utility and marketability. A concerted attempt should be made to find methods for destroying spores at lower critical temperatures. A breakthrough on this problem would do much to enhance the shelf life, flavor and marketability of many food products now of limited merchantable quality.

The Department has carried out a vigorous and thorough study of aflatoxins in cereal and oilseed products. This work has delineated many of the analytical, toxicological and technological problems relating to aflatoxins. This effort is commendable and should be continued and expanded to include other mycotoxins elaborated by various field and storage fungi (see feeds).

Research should be expanded to develop improved methods for sampling and testing food products. Much attention is being given to the control of quality. Cumbersome analytical methods in these programs are of questionable value. Particular emphasis should be placed on simple, rapid, reliable and economical methods for the detection and enumeration of microorganisms including those of public health significance. We need rapid, accurate and simplified methods for detection of Salmonellae organisms in food.

Research should also be expanded to develop rapid practical procedures for the estimation of general sanitary quality of food products. Emphasis should be placed on the development of nonmicrobial techniques for evaluating sanitary quality.

Pasteurization is now an accepted and mandatory step in the processing of egg products, but information is not complete on the effectiveness of the various pasteurization methods on eliminating microorganisms. Work should be continued in developing better pasteurization methods for all egg products giving consideration to costs and retention of maximum functional properties in the pasteurized products. Studies should be conducted on the indigenous microorganisms and their fate after pasteurization by different methods. Additional studies are needed to determine the processing and control steps necessary to avoid post-pasteurization contamination. The mechanism of heat resistance of Salmonellae and the difference in heat resistance between naturally occurring

organisms and laboratory cultures needs clarification. We recommend that studies be continued on the engineering aspects of pasteurization processes.

As more sophisticated methods are developed for the detection of various contaminants, such as pesticide residues, increasing amounts of food and fiber will be considered initially unacceptable for use by humans. Efforts should be made to find means of utilizing these sources of food and fiber. Utilization research might attack this problem from the standpoint of developing techniques for removing, inactivating or destroying these contaminants or developing alternate nonfood uses. Many cereals, oilseeds, legumes and other plant materials are field-contaminated with bacterial or fungal spores, or are exposed to such contamination during processing. It is recommended that work should be undertaken to develop methods of reducing this contamination without adversely affecting functional properties.

Among useful processes to preserve and improve palatability of foods is fermentation. Research should be expanded to develop new methods for improving food quality by fermentation. Of immediate need is a controlled method for bonifying the bland flavor of Thompson seedless grapes so this variety, which is produced in surplus in most years, can become a source of high quality wine.

Feeds

The Department is to be commended for its progress in investigating the nature and scope of the aflatoxin problem in feeds. Yet, mycotoxins arising from the growth of field and storage fungi are a continuing potential threat to the full utilization of feed crops, processed feed crops, and crop residues used for feed. Therefore, an intensified research effort is recommended to define molds and mold strains producing toxic metabolites, to provide methods for the detection of these mold metabolites, to assess the toxicological responses of the metabolites, to define environmental conditions necessary for production of the mycotoxins and then to devise means for the removal or inactivation of the toxic substances.

More information is needed on the constituents of feed crops and processed feed crops that produce undesirable physiological or toxic responses in farm animals and poultry. This work should be stressed as a part of a continuing effort to develop improved feed ingredients from cereal grains, oilseeds and forage crops.

Work must be undertaken to evaluate the contribution of meat- and crop-derived feed ingredients to the contamination of food by undesirable microorganisms, and to develop or define means for adequate control of these microorganisms in feed ingredients and mixed feed processing.

Industrial Products

Cereals

Carbohydrates in cereals, expecially corn, wheat and sorghum, are excellent low-cost raw materials for microbiological and enzymatic conversion to

alcohols, antibiotics, vitamins, amino acids, polysaccharides, and other chemicals. Several of these products are now produced by important industrial processes. Laboratory work should be continued and expanded to discover other potentially useful fermentation type reactions.

Oilseeds

Drying oils in paints continue to suffer serious biodeterioration, particularly in the Southern States and in any localized humid environment. Many years of use of zinc, mercury, copper, arsenic and various organic compounds have not solved the broad problems of maintaining white and colored paint films in fully protective and attractive condition for the time expected. Competition to drying oils increases from vinyl and other synthetic polymers which are factory applied and warranted for 10 to 30 years of service on various substrates such as galvanized steel, aluminum and reconstituted wood. This, coupled with high labor costs of paint application in the field, places air drying paints in a defensive position.

The biodeterioration and continued photochemical vulnerability of oil based paints are major weaknesses deserving of continuing intensive study. These are simply prominent illustrations of similar problems in less obvious structural and decorative products which suffer economic losses in wood, textiles, etc. Basic studies on chemical and physical mechanisms of fungal growth should lead to the design of more effective, longer-lived fungicides, and to the better modification of drying oils to withstand fungal attack.

TECHNOLOGY - PRODUCT AND PROCESS DEVELOPMENT

Foods

Product and process development should involve all aspects of composition, color, texture, flavor, sanitation, nutrition and storage qualities of food, as well as waste disposal and environmental sanitation implications.

While equipment design and development is not the primary role of utilization research, this function should receive major consideration in any development effort. Since most food processors are relatively small and lack resources for such development, the need for complete processes and equipment development by the Department is strongly indicated.

Conservation of water resources and pollution prevention are of universal concern. Since many processing plants are faced with potentially inadequate potable water supplies and waste disposal outlets, this problem is of special concern to the food industry. It is recommended that research programs be initiated to provide processors with detailed information relative to effective water conservation and waste disposal practices and methods. Consideration should be given to the recovery and use of waste products.

New foods providing convenience or improved quality enter our markets at an astounding rate, each one challenging traditional market positions. Competitive products that are easy to serve and that maintain good flavor, texture, freshness, or other desirable qualities are a continuing challenge to food processors. There is interest in providing consumers with additional new and improved convenience foods using combinations of meats, plant proteins, and other ingredients to achieve maximum acceptance and stability.

Utilization research should give increasing attention to developing new food products for domestic convenience markets. Research is needed to develop suitable processing procedures, ingredient selection, and packaging methods to assure optimum product quality. For example, upgrading of the quality and stability of frozen dough products is badly needed to stabilize this new market; controlling the consistency of tomato products will reduce ingredient costs and improve uniformity of product quality; new methods of concentrating juices and purees without heat application will produce products of better flavor; and improving the design of freeze driers will reduce costs of high quality dehydrated foods. Expanded research in packaging of dehydrated, frozen, and convenience foods is necessary to improve quality of the products as marketed and in use.

An area that warrants a great deal of attention in the immediate future relates to the extension of shelf life of foods. Freezing temperatures have been found to be effective in arresting changes that impair quality. However, we need to search for methods of preservation that do not involve freezing or freeze dehydration. The use of temperatures above those that result in the formation of ice crystals and ice formation in the food products should be studied. The use of preservative enhancers should be given attention, such as the use of a gas or a combination of gases to inhibit microbiological and other deteriorative changes. The ultimate goal should be preservation and stability at room termperature for most food products.

Although we may be assured of an adequate supply of natural foods for domestic needs for the next generation or two, at some future time we may need to supplement these natural foods with foods produced through chemical and biological synthesis. Many decades of research and development may be required before many of these synthetic foods can be produced in volume on a low cost basis. The utilization research laboratories should begin giving attention to the development of nonnatural or synthetic food products.

Animal Products

There is need for research that will permit the use of a larger proportion of total U.S. animal fat as edible fat.

The contributions and current activity of the Department in milk process development is gratifying. Substantial progress has been made on refinements of processes for manufacturing concentrated and dry milks. In these processes, more information is needed on the physical-chemical changes in the protein fractions of milk during processing and sterilization. More specifically,

basic information is needed on the protein-protein interactions as influenced by processing conditions as well as the influence of cation binders such as lactate, citrate and carbonate.

With the growing popularity of cheeses in the American diet, continued work on cheese products is definitely warranted. The low-fat cheese recently developed by the Department is an excellent example of product development with far reaching implications.

As applied to poultry, it is urged that investigations designed to improve loading, transporting, dispatching, defeathering, eviscerating, chilling, boning, cooking, packaging, and storing be continued and expanded.

Egg consumption has continued to decline for several years. Research is needed to make eggs sufficiently attractive and useful to encourage their increased utilization. Investigations are encouraged that would develop a technology necessary to permit the production and handling of hard cooked eggs without shells on a commercial scale. This involves development of methods for packaging the eggs, and insuring satisfactory shelf life. Due to the current labor shortage in many processing areas, it is urgent that new and improved equipment and methods of processing be developed and that more operations be automated. Process engineering, equipment design and materials handling developments have not kept pace with basic product technology. As an example, methods for cooling egg powder and avoidance of the recontamination of pasteurized egg products are urgently needed.

Cereals

Valuable information about rice is being developed. This should be continued through (1) "deep milling" investigations, (2) studies on chemical composition and physical properties as related to processing, (3) research on factors which influence the development of favorable flavor and textural characteristics during cooking, parboiling or instantizing, and (4) cooperative programs with State stations and others in the evaluation of new selections and varieties as related to milling and consumer acceptance qualities.

Little research has been reported on dry milling sorghums, even though increased utilization of sorghum is dependent upon the quality and cost of products obtained by milling. Research should, therefore, be expanded to investigate the application of new techniques, such as air classification, impact milling and electrostatic separation, with the objective of developing processes for economical production of high-starch, high-protein, and germ fractions from sorghum. Availability of such processes should provide higher protein fractions for food and feed uses, as well as permit use of greater amounts of sorghum products in industrial applications.

Oilseeds

Protein products and protein concentrates derived from oilseed crops and other agricultural crops are of growing significance in the development and manufacture of food products for domestic consumption and provide an important protein

resource for food in the protein-deficient areas of the world. The food deficits in many countries in the free world provide export opportunities, but further research is needed to meet the export needs most effectively. In most of the deficit areas, the potential for producing additional animal protein is lacking. Nutritious, lower cost and attractive protein concentrates and food products from vegetable sources can fulfill a definite need in many areas with medium to low economic levels.

It is strongly recommended that processing methods be developed to provide new protein products with improved food quality at reduced cost. Serious effort must be devoted to methods which improve the acceptability of these products as food ingredients and enhance their nutritional value. Research is in progress on the conversion of soybeans to food products that will be acceptable to people in protein-deficient countries. This work has already resulted in a superior full-fat flour for use in infant feeding. Because the need is urgent, more rapid progress in developing nutritious and palatable soy foods should be made.

Research on seed protein products should be expanded to include additional engineering and technological studies, accelerated development of new or more effective processing methods, and work on production of low-cost textured protein foods. It should also include evaluation of functional use, nutritive value and economy. As a part of investigations to develop new and improved protein concentrates, attention must be given to utilizing or disposing of by-products and wastes which result from processing such concentrates.

Fruits and Vegetables

In commercial processing, the crop variety is one of the most important factors determining the quality of the finished product. Research should be expanded to evaluate established vegetable and fruit varieties and plant breeders' lines as to their suitability for processing. Because the proportion of vegetables marketed in processed form is constantly increasing, it is imperative that varieties be evaluated for processing suitability as well as for their horticultural characteristics.

High cost and decreasing availability of harvesting labor is rapidly making more and more fruit and vegetable growers dependent upon mechanical harvesters. This problem is particularly troublesome for the processing industry. Machine-harvested fruits and vegetables do not have the uniformity and freedom from bruising that was obtained by trained pickers. Over- and under-mature raw material, burdensome accompaniment of trash and dirt, and increased contamination are by-products of machine harvesting. Research should be materially expanded on solving the processing problems that are created or intensified by mechanical harvesting, especially on new methods for sorting and on new products to use raw material that is not of prime grade.

The changing buying habits of the consuming public require the continuing development of food products of convenience and high level acceptability in order to retain traditional markets and develop new ones for citrus, subtropical

and tropical fruits. Research should be expanded to develop desirable and stable products from these highly perishable commodities--including avocado, papaya, guava, passion, lychee, and mango--using foam-mat, and more conventional food preservation methods. Particular emphasis should be placed on methods of freeze drying.

Feeds

The Committee stresses the continuing opportunity to improve the value of feed crops, crop residues, and crop by-products for feed through the development of new and improved processing methods. With the expanding utilization of certain crops for direct food use, attention must be devoted to alternate sources of feed nutrients, especially those forages and crops not suitable for human consumption.

The development of safflower and crambe as sources of feed protein should be completed so as to provide information which will permit an evaluation of their economic importance. It is recommended that work be initiated on the processing of sunflower as a source of feed protein.

More effort should be devoted to (1) upgrading of millfeeds, hulls, etc., arising during the processing of grains and oilseeds to permit better utilization in high-energy rations, (2) fractionating of forages to provide high and low fiber products, and (3) cooking of cereal grains.

More attention must be devoted to the development of new and improved products for the feeding of farm animals through the microbiological conversion of feed crops, crop residues, and crop by-products and processing wastes.

With a view toward increasing mechanization of poultry and livestock feeding, research should be initiated on the preparation and modification of feed ingredients aimed toward their utilization in liquid feeding systems.

Fibers and Leather

Cotton

Cotton has the advantage of being one of the most easily modified, chemically, of all commercial fibers. Adequate study of processing conditions must be supported at a high level on a pilot plant scale to furnish positive information to industry.

Studies of cotton yarn and fabric construction (with modification) are the basis of new or improved products and this research should be continued.

Cotton of suitable staple length and diameter is in short supply for most cotton mills. There is an abundance of off-quality fiber regarded as below standard for high speed mill processing. Research should be initiated on processing of this subquality cotton through spinning.

Synthetic fiber producers are able to expand their fiber use through blends of the same chemical fiber but of a different physical form. Research should be initiated into blending of chemically modified cotton with native cotton for end uses such as bulk, dyeing properties and other aesthetic qualities not now obtained with unmodified cotton.

Research should be initiated to determine the value of cotton with inorganic fibers such as glass to determine merits, particularly for industrial end uses.

Continued research on cotton batting is urged, particularly using substandard cotton available in surplus.

Cotton fabrics of low level blend with synthetic fibers should be studied for a guide to all cotton products. Research into all forms of polymer deposition on cotton should be continued and expanded where possible. Research into new processing systems such as electrostatic and aerodynomic is applauded and should be continued with every effort made to increase the level of support.

Industrial end uses for cotton depend almost entirely on new technology. Research into all phases of cottons' performance qualities such as rot resistance, fire propensity, etc., should be continued. New industrial markets for chemically modified cottons with unusual properties should be investigated and any indicated research initiated.

The major problems of cotton fiber subjected to chemical treatment to improve strength and abrasion are cost and quality assessment. A strong accelerated program of research to improve strength and abrasion resistance in order to permit cotton to compete with synthetics economically in all avenues of end use is a must.

Wool

Basic studies should be expanded on the effects of pressure, steam and chemical reagents and the physical conditions which produce such desirable changes as permanent setting, permanent press, luster and wrinkle recovery of wool garments.

Since the demand for wool knits has grown in the last few years, basic studies on the factors of construction leading to well stabilized washable sweaters and garments should be expanded. The same holds true for woven fabrics.

Use should be made of interfacial polymerization and chemical grafting techniques to explore the possibilities for providing permanent protection to wool fabrics from insects and microbial attack.

The exploratory work on the mechanical processing of the woolen system should be expanded and the necessary machinery acquired.

It is reemphasized that wool fibers which have been modified by various chemicals such as Wurlan 1 and 2 and physical processes leading to new use attributes should be investigated and studies initiated as to their performance--not only

in 100 per cent wool fabrics, but also in yarns, woven and knitted products made up of blends of these modified wool fibers with cotton and man-made fibers. A good example will be a blend of modified wool fibers with cross-linked or resin treated cotton fibers. Preliminary experiments indicate that a completely washable no-iron garment can be achieved from such a blend.

With the present low market for mohair, processing experiments should be started on the spinnability of 100 per cent mohair in connection with a study to eliminate Kemp fibers which are responsible for defects in the finished fabrics.

Leather and Hides

It is noted that no research has been started on the Committee's recommendation for study of handling of hides in foreign countries. This study should be done as additional knowledge can be gained. Research to protect hides during storage and handling is most important to the future of leather and this should be emphasized.

Work on water repellant chemicals should be investigated for its potential value on leather products. In view of the diminishing market for hides resulting from the inroad of synthetic products, new markets must be found through research on the dispersion and regeneration of collagen into nonconventional products. There is a definite need for new research on engineering aspects of leather making and processing operations to improve the overall economics.

Laboratory review of synthetic materials should be extended to learn first-hand their attributes and determine whether natural leather can meet or exceed them. The work on the addition of preformed polymers to leather to give new features should be increased.

Investigation of cuttings and edges of hides for the creation of new leather-like products with new features should be continued. The investigation on leather making should be extended from the standpoint of improving processes and cutting costs, such as has been achieved by glutaraldehyde tanning.

Industrial Products

Animal Products

The 4.5 billion pounds per year output of inedible animal fats is one of the two most important by-products of the livestock industry. During the past fifteen years production has doubled, while use in soap declined by half. Work to develop new chemicals from inedible fats, which are useful in such large volume outlets as plastics, plasticizers, lubricants, lubricant additives and biodegradable detergents, should be expanded.

Cereals

One of the largest volume industrial uses of any agricultural product is the use of starch in the paper industry. The new papermaking equipment at the Northern Division is suitable for testing new products for this industry. Exploratory work to expand the uses of various types of modified and unmodified starch products as sizing, adhesive, and binder materials should be continued and broadened. It is suggested also that by-products of agricultural processing such as hulls from the milling of corn, soybeans, wheat, sorghum, safflower, sunflower and rice be reevaluated, possibly in the form of xanthates, as components in paper manufacture.

Work on the preparation of amylose starch films should be continued as new starches with higher amylose levels become available from breeding programs. Various cereal xanthides and xanthates need to be evaluated as wet strength additives in the pilot scale papermaking equipment. If additions of these products appear economically practical, tests should be extended to full plant scale evaluation.

Many new starch derivatives are being prepared in the laboratory and more research effort is needed to evaluate their potentials in the plywood, coatings, paper, and mineral ore industries.

Process studies on improved methods of dry milling and fractionation of cereals should be continued and expanded, especially to provide low cost products for industrial uses.

Another area worthy of additional exploration is the use of cereal or protein binders in the pelletizing of powdered ores prior to sintering. In the same area, some consideration is justified on the use of starches and starch derivatives in the flotation of various ores. Suitable products should command substantial usage in such a large volume industry.

Recently there has been some commercial interest in special varieties of corn, including the stalks, for production of liquid sugars. Some exploratory work on the refining of high sugar corn juices is indicated. The resulting syrups may be expected to have industrial applications in addition to their use in the food and beverage industry if the process is successful.

Oilseeds

The several laboratories are to be commended generally for ingenuity in seeking novel chemical reactions to increase the use of oilseed components. From their now classical development of epoxy oils on to aldehyde oils, keto stearates and intermediates toward urethanes, their staffs have shown wide competence. Rather than resist the impact of petro-chemicals on our economy, the trials of low cost chemicals such as ethylene carbon monoxide, ammonia, acrylonitrile and other such petro-chemicals in combination with glyceride oils has lead to interesting new products. Work in this direction should continue.

It is axiomatic that the proof of values of these new intermediates is a long and complex task requiring diverse skills from various industries. Broader, faster dissemination of these basic findings to industry is needed, both for better utilization by industry and as a critical guide to in-house development of products from the basic work. Better, faster counsel by industry can save money in diverting product development from unlikely goals. Earlier disclosure through industry oriented journals is suggested.

Castor oil modifications toward urethane, plasticizer, lubricant and other end uses are commendable and work on them should continue.

Linseed oil polymerization to higher molecular weights and lower vulnerability of its dried films to weather continue as important goals. Air pollution control and convenience of application increase the need for water dispersed paints for both interior and exterior use, and in high, medium and low levels of gloss. More complete polymerization in manufacture--while still being easily dispersed in liquid paint, then fully coalesced in dried films--appears desirable, though difficult. Techniques for this should be applied not only to linseed but to other drying and semidrying oils. Other novel polymerization systems may yet be found from high energy radiation or unique radiation frequencies and these as well as diverse chemical catalysts should be sought more vigorously.

Heavy duty, chemically converted coatings, preferably with little or no solvent to pollute the air, are growing in use and in demand. Fast, complete conversion reactions are essential for their success. All of the glyceride oils, or even other components of oilseeds should be viewed as starting materials for novel chemical intermediates toward their use. There is no limit to chemical ingenuity which can be applied to this problem.

Suspension of work on tung oil for a time is not unreasonable as the domestic tung oil industry matures and finds its place in our economy. The venerable history of this product as "China Wood Oil" implies long and useful art, as well as modern science and technology. A great amount of scattered lore and scientific and technical details in scattered places deserve to be preserved through the preparation of a monograph comprising a critical review of all aspects of culture, production and use of tung oil. This can best be done through a cooperative effort by the Department and the tung industry.

Sunflower seed, and oil therefrom, looms as a possible big, new domestic crop worthy of much attention to all of its aspects. Sunflower seed oil, already the major cooking and salad oil in Russia, may also compete with or supplement other oilseeds in our Northern States beyond the usual range for corn and soybeans. New strains of sunflower seed with oil contents up to 45 per cent and goals of up to 2000 pounds of seed per acre imply a broad responsibility to study utilization of oil, meal and hulls as well as the usual problems of growth, cultivation disease control, etc. Comparisons are needed between sunflower oil, as a food oil, and other edible oils. As an industrial oil, it should be compared with products coated with linseed, safflower and soya oils. It once had an historic unique use in nonyellowing alkyds in air-drying paints.

Naval Stores

Products from terpenes are being given sufficient attention by private industry. Surplus stocks of gum rosin, among the three classes of rosins, constitute the main challenge toward high ingenuity in finding a sophisticated end use which will not have to compete against low cost, high volume monomers and polymers derived from petroleum. Rapid changes in end use patterns of paints and papers, new legislation against air pollution from solvents, and mounting competition from surfaces produced in factories make obsolete many of the coatings goals of the last two decades. Thick, pale, heavy duty, seamless flocr coatings and exterior finishes with warranties of 10- to 30-years of useful life are illustrations of trends. Rosin acids must have all their chemical reactivity utilized constructively before and in film formation to compete successfully in this field. Otherwise, high rosin cost or poor product yields will lose out in competition against low cost petro-chemicals.

Epoxy, carboxyl and isocyanate groups are illustrative of the modifying groups which ought to be built into the rosin molecule so that more nearly all of its vulnerability is used up before it is subjected to environmental degradation. The Department is commended on its accomplishments in this direction to date, and encouraged to continue.

Annual Fibers

With a new paper making facility available for research, the use of annual fiber crops, such as kenaf, in the pulp and paper industry needs pilot plant development. If economically attractive products can be made in the pilot plant, the process should be extended to larger scale tests in a commercial plant.